PB84-171677

Draft Environmental Impact Statement (DEIS), Red Dog Mine Project, Northwest Alaska

(U.S.) Environmental Protection Agency
Seattle, WA

Feb 84

U.S. Department of Commerce
National Technical Information Service
NTIS

EPA

DOI

United States
Environmental Protection
Agency

Region 10
1200 Sixth Avenue
Seattle WA 98101

EPA 910/9-83-111

February 1984

Water

EPA-10-AK-Wulik-NPDES-84

PB84-171677

United States
Department of
Interior

Post Office Box
100120
Anchorage AK 99510

Environmental Impact Statement

Draft

Red Dog Mine Project
Northwest Alaska

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

7

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. EPA 910/9-83-111

2.

3. Recipient's Accession No. PB84 1[illegible]1677

4. Title and Subtitle

DRAFT ENVIRONMENTAL IMPACT STATEMENT
RED DOG MINE PROJECT

5. Report Date February 1984

6.

7. Author(s)

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Same as box 12.

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.

(C)

(G)

12. Sponsoring Organization Name and Address

U.S. ENVIRONMENTAL PROTECTION AGENCY REGION 10
1200 6th AVENUE
SEATTLE, WA 98101

13. Type of Report & Period Covered

Draft

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The actions to be considered are the approvals of permits for the proposed Red Dog Mine Project in northwestern Alaska. The mine area facilities would be located on private land owned by the NANA Regional Corporation. A transportation corridor would be constructed from the mine to a port site on the Chukchi Sea/ Three action alternatives and a No Action Alternative are discussed. Rationale is given why various options were eliminated from consideration. The preferred alternative would traverse Cape Krusenstern National Monument. Impacts of the proposed project are described as they relate to vegetations and wetlands, wildlife, water quality, fisher resources, physical and chemical oceanography, air quality, visual resources, cultural resources, subsistence, socioeconomics, recreation, technical complexity, cost and Cape Krusenstern National Monument.

17. Document Analysis a. Descriptors

Environmental Impact Statements
Mining

b. Identifiers/Open-Ended Terms

Red Log Mine

c. COSATI Field/Group

18. Availability Statement:

19. Security Class (This Report)

20. Security Class (This Page)

21. No. of Pages

22. Price

(See ANSI-Z39.18)

See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

TO: All Interested Government Agencies, Public Officials, Public and Private Groups and Citizens

Pursuant to Section 102(2)(c) of the National Environmental Policy Act of 1969 and implementing Federal Regulations, the U.S. Environmental Protection Agency (EPA) and U.S. Department of the Interior (DOI) are forwarding for your review and comment this Draft Environmental Impact Statement (DEIS) on the proposed Red Dog Mine Project. The Red Dog mineral prospect (lead, zinc, silver and barite) is located in the De Long mountains of Northwest Alaska on lands owned by the NANA Regional Corporation. Through an agreement with NANA, Cominco Alaska proposes to develop an open-pit mine with adjacent ore milling facilities, and to construct a transportation system that would include a regional transportation route and saltwater port on the Chukchi Sea for shipping ore concentrates to foreign and domestic markets.

Cominco Alaska has applied to EPA for a National Pollutant Discharge Elimination System (NPDES) permit to discharge pollutants from the mine site to navigable waters pursuant to the provisions of the Clean Water Act (Public Law 95-217). The proposed mine and mill facility has been determined to be a New Source under Section 306 of the Clean Water Act and, according to Section 511(c)(1) of the Clean Water Act, is subject to the provisions of the National Environmental Policy Act. The draft New Source NPDES permit has been released for concurrent public review with this EIS (Appendix 4).

As a cooperating agency for the EIS, the Alaska District Corps of Engineers (Corps) under the authority of Section 10 of the River and Harbors Act of 1899 and Section 404 of the Clean Water Act, will evaluate Cominco Alaska's proposed activities in certain waters of the United States in the vicinity of the mine site. Appendix 5 of the EIS contains a complete description of the proposed activities requiring Department of the Army (DA) authorization.

Cominco Alaska has also filed a consolidated Alaska National Interest Lands Conservation Act (ANILCA) Title XI application with the DOI, EPA, and the Corps for Federal permits required for the development of the proposed transportation system. The following permits are covered by the consolidated Title XI application and this DEIS:

°A DOI National Park Service (NPS) Right-of-Way Permit to construct a transportation route through Cape Krusenstern National Monument

°An EPA NPDES permit for a sanitary waste discharge from the port facility

°DA permits for proposed activities in certain waters of the United States that would be affected by the transportation system,

The consolidated Title XI application for these permits is included as Appendix 6 of the DEIS.

Substantive comments are invited on the DEIS, Draft NPDES permit, Title XI application and all related permit decisions and will be considered in the preparation of the final EIS and the various permit Records of Decision.

Public hearings on the DEIS, the draft New Source NPDES permit, the Title XI application and DA authorization are scheduled for the following locations and times:

WASHNGTON, D.C.	ANCHORAGE	KOTZEBUE
April 24, 1984 Room 7000 B Main Interior Bldg. 18tn & C St. N.W. 1:00 PM	May 2, 1984 Nat. Park Srv. Office Room 110 2525 Gambel St. 7:30 PM	May 3, 1984 NANA Museum 7:30 PM

EPA and DOI will announce the availability of this document in the Federal Register on Friday, March 16, 1984, initiating a 60-day review and comment period. Comments should be submitted by May 14, 1984, to:

William M. Riley
EIS Project Officer
Environmental Evaluation Branch M/S 443
Environmental Protection Agency
1200 Sixth Avenue
Seattle, WA 98101

Telephone: (206) 442-1760

DRAFT

ENVIRONMENTAL IMPACT STATEMENT

RED DOG MINE PROJECT

Prepared by

U.S. ENVIRONMENTAL PROTECTION AGENCY (Region 10)
and
U.S. DEPARTMENT OF THE INTERIOR

- National Park Service
- Bureau of Land Management
- Fish and Wildlife Service

Cooperating Agency

U.S. Department of the Army
Corps of Engineers

With Technical Assistance From

Ott Water Engineers

RESPONSIBLE OFFICIALS:

Ernesta B. Barnes
Regional Administrator
Environmental Protection Agency
Region 10
Date: February 14, 1984

Paul D. Gates
Regional Environmental Officer
Department of the Interior
Alaska
Date: February 14, 1984

COVER SHEET

DRAFT ENVIRONMENTAL IMPACT STATEMENT (DEIS)
RED DOG MINE PROJECT
NORTHWESTERN ALASKA

Co-Lead Agency: U.S. Environmental Protection Agency

Responsible Official: Ernesta B. Barnes
Regional Administrator
Environmental Protection Agency
1200 Sixth Avenue
Seattle, WA 98101

Co-Lead Agency: U.S. Department of the Interior
° National Park Service
° Bureau of Land Management
° Fish & Wildlife Service

Responsible Official: Paul D. Gates
Regional Environmental Officer
Department of the Interior
Box 100120
Anchorage, AK 99510

Cooperating Agency: U.S. Army Corps of Engineers

Abstract of DEIS

The actions to be considered are the approvals of permits for the proposed Red Dog Mine Project in northwestern Alaska. The mine area facilities would be located on private land owned by the NANA Regional Corporation. A transportation corridor would be constructed from the mine to a port site on the Chukchi Sea. Three action alternatives and a No Action Alternative are discussed. Rationale is given why various options were eliminated from consideration. The preferred alternative would traverse Cape Krusenstern National Monument. Impacts of the proposed project are described as they relate to vegetation and wetlands, wildlife, water quality, fishery resources, physical and chemical oceanography, air quality, visual resources, cultural resources, subsistence, socioeconomics, recreation, technical complexity, cost and Cape Krusenstern National Monument.

Public DEIS Review and Comment Process

This DEIS is offered for review and comment to members of the public, special interest groups and agencies. Public meetings/hearings will be held in Kotzebue, Anchorage and Washington D.C. to discuss the document. Announcements of these meetings/hearings will be made by local newspapers and other appropriate media. Comments received on the DEIS will be addressed in the final EIS.

Location of Technical and Reference Reports and Appendices

Copies of the major reports relating to the Red Dog EIS will be available at the following locations:

EPA Region X Headquarters
1200 Sixth Avenue
Seattle, WA 98101

EPA
3200 Hospital Drive
Suite 101
Juneau, AK 99801

Department of the Interior
1689 'C' Street
Anchorage, AK 99501

Ott Water Engineers, Inc.
4790 Business Park Blvd.
Building D, Suite 1
Anchorage, AK 99503

Maniilaq Association Offices
Shore Street
Kotzebue, AK 99752

Noel Wein Public Library
1215 Cowles
Fairbanks, AK 99701

Z. J. Loussac Library
524 West 6th Avenue
Anchorage, AK 99501

Deadlines for Comments: May 14, 1984

Address all Comments To:
William M. Riley
EIS Project Officer
Environmental Evaluation Branch
(M/S 443)
Environmental Protection Agency
1200 Sixth Avenue
Seattle, WA 98101
Telephone: (206) 442-1760

SUMMARY

INTRODUCTION

Cominco Alaska, Inc. proposes to develop the Red Dog mineral prospect 131 km (82 mi) north of Kotzebue in northwestern Alaska. The proposed mine site is located on Red Dog Creek, just west of Deadlock Mountain in the De Long Mountains of the western Brooks Range. The project would consist of an open pit lead/zinc mine and concentrator located 75 km (47 mi) inland, with interconnecting transportation facilities and shipping facilities located at the coast. The mine, mill, tailings pond, housing and water supply facilities would all be located on private lands owned by the NANA Regional Corporation as part of a 8,975 ha (22,176 ac) parcel in the Red Dog Valley.

The NANA Regional Corporation obtained selection rights to the Red Dog mineral prospect with passage of the Alaska National Interest Lands Conservation Act (ANILCA) in 1980. After the establishment of its right to the Red Dog deposit, NANA selected Cominco Alaska, Inc. as a partner to aid in the development of the project.

The agreement between NANA and Cominco for development of the Red Dog mine represents a melding of environmental, social, cultural and economic interests. The intent of the agreement is to allow development in a manner that provides for: a long-term economic base for the NANA region; jobs for NANA shareholders and other Alaskans; a source of lead/zinc concentrates and an economic return for Cominco; and minimal impacts on the region's social, historical, cultural and subsistence lifestyles.

The EIS process began in January 1983 with the U.S. Environmental Protection Agency (EPA) as lead federal agency. A unique feature of the Red Dog project is that the preferred alternative would involve a transportation corridor through Cape Krusenstern National Monument. This would require consideration of the specific requirements mandated by Title XI of ANILCA for acquiring a right-of-way across the Monument. On November 7, 1983 Cominco made a formal Title XI application to the National Park Service (NPS). Cominco's application was the first ever filed. At that point, the U.S. Department of the Interior (DOI) became co-lead agency with EPA for the EIS process. Title XI applications were also filed with EPA and the U.S. Army Corps of Engineers (Corps).

In June 1983 NANA began separate discussions with the NPS for a land exchange. This exchange, if successfully negotiated and implemented, would alter the northwest boundary of the Monument to exclude lands surrounding the preferred transportation corridor, thereby making a Title XI permit unnecessary. If the preferred alternative was developed with a land exchange, the environmental impacts would be similar.

PROJECT DESCRIPTION

It is important that the reader understand the relationship among the terms "component", "option" and "alternative". The project has several components, each one a necessary part of an entire viable mining project (e.g., the mine, mill site, tailings pond, transportation system, port site, etc.). For each component there may be one or more options (e.g., a northern and a southern transportation corridor option). An alternative is a combination of options (one for each component) that constitutes an entire functioning project.

Development of the Red Dog mine project would involve an open pit lead/zinc mine. While the deposit has not yet been fully defined by geologists, at least 77 million Mg (85 million tons) of ore exist. The ore is estimated to contain approximately 5.0 percent lead, 17.1 percent zinc, 75 g/Mg (2.4 oz/ton) silver and measurable levels of barite. The project has a potential life of at least 40 years under expected production rates, with the possibility of extension if additional ore is found.

The ore would be crushed, and metallic sulfides would be concentrated using a selective flotation process in a mill near the mine site. No reduction of sulfides to base metals would take place at the project site. The upgraded concentrates would be sent outside Alaska for processing to refined metals. Initially, about 434,450 Mg/yr (479,000 tons/yr) of combined concentrates would be transported to the coast for shipment to world markets. After five years, expanded production of about 683,878 Mg/yr (754,000 tons/yr) of combined concentrates would be shipped.

A 237 ha (585 ac) tailings pond would be created on the South Fork of Red Dog Creek. The tailings pond dam would be in the form of an impervious earth-filled structure with a spillway designed to maintain structural integrity in the event of an overflow. The pond would contain thickened tailings slurry from the mill process, in addition to surface and subsurface waters with known toxic concentrations of metals. Chemical treatment and metals removal of tailings pond water would occur prior to discharge to Red Dog Creek. A seepage contingency dam would be constructed downstream of the main tailings pond dam to collect any seepage and return it to the tailings pond.

An approximately 25 ha (63 ac) water storage reservoir would be located on Bons Creek at the south end of Red Dog Valley. This reservoir would serve as the water supply for all aspects of the milling process, as well as for domestic use.

A gravel road to the coast would be 9 m (30 ft) wide and composed of granular fill about 2.0 m (6.5 ft) thick to prevent degradation of permafrost. The proposed northern transportation corridor would be about 117.0 km (73.1 mi) long and would require the construction of six major bridges, six minor bridges and about 300 culverts. The proposed southern corridor would be about 89.9 km (56.2 mi) long and would require one major bridge, four minor bridges and about 182 culverts.

Though operations at the mine and mill would continue year-round, activity at the port site would be limited to the receipt of supplies and fuel during the summer sealift, and the shipment of concentrates from late June until early October. Climatic constraints on shipping activities thus require that adequate storage facilities for concentrates, fuel and other supplies exist at the port site. Only emergency and temporary ship loading crews would be housed there.

Two methods to transfer concentrates from the port site storage facility to ocean going vessels are included in the alternatives: a short causeway/lightering transfer system and a short causeway/offshore island transfer system. Both systems would use a 122 m (400 ft) causeway/dock structure as an interface between the shore and the concentrate loading vessels or offshore island. The lightering system would use two 4,535 Mg (5,000 ton) lighters and two support tugs to transfer concentrates from the dock directly to the side of a moored ocean-going ship. The offshore island system would use an approximately 226,750 Mg (250,000 ton) surplus oil tanker which would be ballasted to the bottom about 1,097 m (3,600 ft) from shore. This approximately 305 m (1,000 ft) tanker "island" would serve as an offshore dock for loading/unloading smaller, ocean going ships.

Cominco's most probable development schedule shows the winter of 1985-86 as the beginning of construction. The construction period would last a minimum of 24 months with mining beginning in 1988. The actual beginning of construction would depend on world economic conditions, ability to complete detailed engineering design, and the progress of the environmental permitting process.

EXISTING ENVIRONMENT

The Red Dog project area encompassing the mine, mill, housing and tailings pond sites, and the transportation corridor and port site options, fall within the northwestern corner of the NANA Regional Corporation's boundaries. Nearly all of the study area is undeveloped and is within the so-called unorganized borough. That is, it is outside any incorporated city or borough governmental jurisdiction. Only the mine area facilities in Red Dog Valley and a thin strip immediately to the south would fall within the North Slope Borough.

The project area is characterized by moderately sloping hills, broad stream valleys and coastal lowland lagoon systems. The entire area is underlain by permafrost. Gentle, poorly defined surface undulations are caused by patterned ground, old drainage channels, thaw lakes, and other depositional, erosional or permafrost related features. The seasonal thaw or active layer varies throughout the area. It generally ranges from 50 to 100 cm (20 to 39 in) deep in vegetated areas and may range up to 3 m (10 ft) deep on exposed, rocky hillsides.

Vegetation types at the mine site, along the transportation corridors and at the alternate port sites range from xerophytic (dry-adapted), upland mat and cushion tundra to wet, lowland sedge-grass marsh. Vegetation consists primarily of cotton-grass tussock tundra, low shrublands and herbaceous meadows, in order of relative abundance.

Waterfowl and shorebird use of the project area is centered along the coast during the spring and fall migrations, although coastal and inland breeding occurs. Portions of the project area provide good habitat for cliff nesting raptors including the endangered peregrine falcon, golden eagle, gyrfalcon and the rough-legged hawk.

Five large terrestrial mammal species are found in the project area: caribou, muskoxen, moose, Dall sheep and brown bear. The Arctic caribou herd, numbering approximately 190,000 animals and the largest herd in North America, encompasses the project area within its range. Caribou use the Asikpak, Kivalina, Wulik and Omikviorok River drainages, and probably the Singoalik River drainage, for winter range. A small herd of muskoxen appears to be established on winter range in the Rabbit Creek Valley south of the Mulgrave Hills. A larger herd is established to the northwest in the Cape Thompson area. Moose are found in the region closely associated with riparian tall shrub communities along major rivers and streams, particularly during the winter. Dall sheep habitat in the project vicinity is limited to the Wulik Peaks and the mountains bordering the headwaters of the Wulik River and Ikalukrok Creek. Brown bears are found throughout the project area. Other important terrestrial mammals include the wolf, wolverine and red fox.

Water quality in the major rivers of the project area, the Kivalina, Wulik and Omikviorok, is typical of unpolluted fresh water in the Arctic. These rivers are clear water streams with low levels of color, suspended solids, turbidity and nutrients. Ikalukrok Creek has similar water quality characteristics, except below its confluence with the lower quality waters of Red Dog Creek. The waters of Red Dog Creek are atypical of most undeveloped Arctic streams because of the toxic concentrations of cadmium, lead, zinc and iron that enter the main stem of the creek as it flows through the highly mineralized Red Dog ore body. Waters not affected by the ore body in the upper portion of the main stem, the North Fork, and most of the South Fork exhibit high water quality.

Important fishery resources in the Kivalina, Wulik and Omikviorok River drainage systems include Arctic char, Arctic grayling and various salmon species.

Important marine fish found in the area include starry flounder, Arctic flounder and saffron cod. Marine mammals present include ringed, spotted and bearded seals, harbor porpoise, beluga, and the endangered Gray and bowhead whales.

Wind and wave conditions along the coast have a significant effect on sediment transport. Long-term net transport is generally in a southeasterly direction. The Chukchi Sea typically has relatively warm, low salinity water present near shore. Sea ice generally begins to form on the coast in early October, but periodic high winds and waves may delay formation of a solid cover until January. The ice cover usually disappears by early July.

The earliest known prehistoric cultural remains in the vicinity of the Red Dog project area are located on a series of beach ridges at Cape Krusenstern, and form the core of the Cape Krusenstern National Monument. A major portion of the project area is within the Cape Krusenstern Archeological District. The known major archeological sites for which the Monument was created are located on beach ridges. Inland, archeological sites are more scattered and indicate a less intensive settlement pattern involving limited use. Beach ridge sites would not be subject to impact. Known inland sites within the Monument or within the Cape Krusenstern Archeological District would be avoided by project design. The easily visible concentration of houses and occupied beach ridge sites in the Monument are often used as a diachronic model of human life in northwestern Alaska. Sites within the Red Dog project area are typical of the region and consist of surface scatters, or shallowly buried deposits of lithic materials that were used in making stone artifacts.

Subsistence is vital to the economic well being and nutrition of most of the region's residents. Approximately 55 percent of all households obtain half or more of their food supply by subsistence hunting, fishing and gathering. In a region where imported foodstuffs are costly and cash income depressed, the economic importance of the subsistence food supply is evident.

SCOPING

The EIS scoping process identified the following 12 issues of concern for the project:

- Maintaining the quality and quantity of water
- Maintaining the quality and quantity of fishery habitat, and minimizing disruption of fish movements
- Maintaining the quality and quantity of wildlife habitat, and minimizing impacts on wildlife
- Minimizing impacts on coastal geologic processes
- Minimizing impacts on marine life
- Protecting subsistence resources and their use
- Protecting cultural resources
- Minimizing the social, cultural and economic impacts on residents of the region
- Designing project components from a regional use perspective
- Impacts on Cape Krusenstern National Monument
- Technical feasibility
- Economic feasibility

OPTIONS SCREENING PROCESS

To address those 12 issues, the scoping process also identified a total of 30 options and seven suboptions for the 11 project components (see first column of Table 1 for list of components). To determine reasonable options, a two-step options screening process was conducted. In the first step all options were reviewed to eliminate from further consideration those which were clearly unreasonable or infeasible primarily for environmental or technical reasons. This resulted in 11 options and one suboption being eliminated.

In the second step, the remaining options were individually evaluated in detail from the perspective of each resource or technical descipline (e.g., water quality, wildlife, subsistence, technical feasibility). For each discipline, a specific set of "options screening criteria" was used to identify potential impacts for each option. Then, each option was compared to all other options for each of the 11 components to identify the best option (i.e., the one with the least potential impacts) for each component.

Following the options screening process, the best options for eight of the 11 components were relatively easy to identify. However, three components (transportation corridor location, port site location and marine transfer facility) had two options each which adequately addressed one or more of the 12 issues. These options were therefore retained and, with the other eight options, were used to form the alternatives (Table 1).

IDENTIFICATION OF ALTERNATIVES

The identification of alternatives process was relatively straightforward as there were only three combinations (and hence alternatives) necessary to address the issues raised by the three components with more than one option remaining. The three action alternatives and the no action alternative for the Red Dog project are described below.

Alternative 1

This alternative would site the tailings pond in the South Fork of Red Dog Creek with the mill in close proximity to the west. A worker camp would be located close to the mill. Power would be supplied by diesel generators also sited near the mill. Water would come from an impoundment on Bons Creek to the south of the tailings pond and airstrip. All these facilities, as well as the mine, would be located on private land owned by NANA.

Transporation would be by year-round road along the southern corridor to a port site at VABM 28 on private NANA land within the boundaries of Cape Krusenstern National Monument. The transfer facility would be the short causeway/offshore island.

Alternative 2

This alternative is the same as Alternative 1 for all components except the transportation corridor and port site locations. It includes the northern transportation corridor to a port site at Tugak Lagoon.

Table 1

OPTIONS USED TO FORM ALTERNATIVES

Component	Option(s)	Suboption
Mine Location	Fixed	
Tailings Pond Location	South Fork Red Dog Creek	
Mill Site Location	South Fork Red Dog Creek	
Worker Housing		
Type	Campsite	
Location	South Fork Red Dog Creek	
Water Supply	Bons Creek	
Power Generation	Diesel	
Transportation		
Corridor Location	Northern	Asikpak Route
	Southern	Kruz Route
System	Road	Year-round
Port Site		
Location	Tugak Lagoon	
	VABM 28	
Transfer Facility	Short Causeway/Lightering	
	Short Causeway/Offshore Island	

Alternative 3

This alternative is the same as Alternative 1 except that the transfer facility would be the short causeway/lightering option instead of the short causeway/offshore island option.

No Action Alternative

The No Action Alternative is defined as meaning no development of the Red Dog Project would occur. The No Action Alternative would result from denial of at least one, or perhaps more, of the federal or state permits necessary for project development. Or, it could mean that the project sponsor chose not to undertake the project.

COMPARISON OF ALTERNATIVES

The impacts of each of the three action alternatives were compared by an evaluation against the 12 issue criteria identified during the scoping process (Chapter III). The quantified impacts of each alternative (Table 2) were then compared for identification of the preferred alternative.

IDENTIFICATION OF PREFERRED ALTERNATIVE

Alternative 1, comprised of the southern corridor, VABM 28 port site and the offshore island facility, has been identified by the co-lead agencies as the preferred alternative.

The preferred alternative would require a road through Cape Krusenstern National Monument, and, therefore, an ANILCA Title XI permit would be needed. This would require a finding that the transportation system would be compatible with the purposes for which the Monument was established, and that there was no economically feasible and prudent alternative route for the system. The Title XI application was filed by Cominco with the NPS, Corps and EPA, each of which has land management and/or permitting responsibility for the project. This application is undergoing review by the NPS, Corps and EPA. A copy of the Title XI application and agency review comments are included in this document as Appendix 6.

ENVIRONMENTAL CONSEQUENCES OF THE PREFERRED ALTERNATIVE

The mine area facilities (mine, tailings pond, mill site, worker housing, water supply, airstrip and all associated access roads) would directly disturb a total of about 541 ha (1,336 ac) of vegetation in Red Dog Valley. Development and operation of these facilities might have an indirect impact upon caribou by displacing some animals from marginal winter range. This impact would not be significant on more than a local basis and no other wildlife species would be significantly impacted.

Ninety-five percent of the metal loads in the main stem of Red Dog Creek above the South Fork come from an area bounded by the exposed ore zone. Since this area would be developed, with runoff diverted to the tailings pond where water treatment would occur prior to discharge, water quality in the naturally contaminated main stem of Red Dog Creek could improve. There would be no significant impacts on fishery resources from mine area facilities.

Four archeological sites are located in the immediate area of the mine site. Two of these could not be avoided during ore removal, and therefore they would be evaluated for eligibility to the National Register of Historic Places. If eligible, mitigation actions would be included in the Advisory Council on Historic Preservation (ACHP) commenting procedures covered by a Memorandum of Agreement concluded among the State Historic Preservation Officer (SHPO), the ACHP, and the federal agencies permitting the project. Wherever feasible, road alignments and other facilities would be designed to

Table 2

EVALUATION CRITERIA MATRIX SHOWING RELATIVE TOTAL IMPACT VALUES ASSIGNED TO THE THREE ACTION ALTERNATIVES

Evaluation Criteria	ALTERNATIVE 1 Southern Corridor VABM 28 Port Site Offshore Island Fac.	ALTERNATIVE 2 Northern Corridor Tugak Lagoon P. S. Offshore Island Fac.	ALTERNATIVE 3 Southern Corridor VABM 28 Port Site Lightering Facility
1. Minimize Risk of Water Quality Degradation	Low Risk	High Risk	Moderate Risk
2. Minimize Impacts to Fish and Fish Habitat	Low Impact	High Impact	Moderate Impact
3. Minimize Impacts to Wildlife and Wildlife Habitat	Low Impact	High Impact	Low Impact
4. Minimize Impacts to Coastal Geologic Processes	Low Impact	Low Impact	Low Impact
5. Minimize Impacts to Marine Life and Marine Habitat	Low Impact	Low Impact	Moderate Impact
6. Minimize Impacts to Traditional Subsistence Harvest Activities	Low Impact	High Impact	Moderate Impact
7. Minimize Impacts to Cultural Resources	Low Impact	Low Impact	Low Impact
8. Minimize Social, Cultural and Economic Impacts upon Residents of the Region	These impacts would be similar for all three alternatives.		
9. Maximize the Potential for Other Regional Uses	High Potential	High Potential	Moderate Potential
10. Minimize Impacts on Cape Krusenstern National Monument	High Impact	Low Impact	Moderate Impact
11. Minimize Technical Complexity	Moderate Complexity	High Complexity	Moderate Complexity
12. Minimize Costs	Low Cost	High Cost	Moderate Cost

avoid direct impact to these sites. If sites could not be reasonably avoided, recovery operations would be conducted to preserve the site data. The mine site vicinity possesses little value for subsistence or recreational fishing and hunting, and no significant impacts would be anticipated.

Construction of the southern transportation corridor from the mine area through Cape Krusenstern National Monument to the coast at VABM 28 would directly disturb a total of about 197 ha (487 ac) of vegetation. Several nest sites of birds of prey, including three of the endangered peregrine falcon, have been reported along the southern corridor. The peregrine nests would not be significantly impacted because the road alignment has been altered to provide a buffer of at least 3.2 km (2 mi) around the nests. The corridor passes through presently used caribou winter range. Indirect habitat loss for caribou would likely be significant only on a local basis, but could, as other developments occurred in the region, be significant on a greater than local basis if changes to historical caribou migrations occurred.

Impacts on hydrology and water quality would be insignificant as proper methods of road construction and drainage control would be followed. The road would cross 11 streams which are known to contain fish, but no significant impacts to fish movements or spawning and/or rearing habitat would be expected.

Construction of the southern corridor could impact 12 archeological sites, six within Cape Krusenstern National Monument. All reasonable measures would be taken to avoid these sites by realigning the road. Recovery operations would be conducted under terms of the Memorandum of Agreement to preserve the site data and material that could not be preserved in place.

Construction of the port site would directly disturb about 20 ha (50 ac) of vegetation. No terrestrial wildlife species would be significantly impacted on greater than a local basis. Port Lagoon would be breached to shelter barges during construction and operation, but impacts to fish and invertebrate species would be insignificant. Construction of the transfer facility would also have minimal impact on anadromous and marine fish, as well as on marine birds and mammals.

Impacts from the alteration of sediment transport patterns by the port site causeway would be insignificant on more than a local basis. Port site construction could increase sediment loading for a short period, but long-term impacts on marine water quality would be insignificant. Potential impacts from spills of fuel, concentrates or mill reagents would be expected to be insignificant on greater than a local basis.

The remains of the historical reindeer herding facility at the VABM 28 port site could be directly or indirectly impacted by the port facilities. Recovery and recording operations would be developed if the site could not be avoided by redesigning the facility.

Marine mammal hunting is generally confined to the winter and spring months when the port would be ice-bound, so ship traffic from the port should not significantly disrupt susbistence harvest activities. Port construction and noise from year-round activities aboard the offshore transfer facility would likely displace some marine mammals from the immediate area.

Although the majority of the area is on private and state land, the de facto wilderness nature of the project area would be permanently altered with the loss of wilderness characteristics such as solitude and the opportunity for primative types of recreational experiences.

TABLE OF CONTENTS

Page

COVER (Photo: The Wulik River flowing from the De Long Mountains to the Chukchi Sea.)

COVER SHEET i

SUMMARY iii

INTRODUCTION 1

I. PURPOSE OF AND NEED FOR ACTION

INTRODUCTION I-1

DESCRIPTION OF PROPOSED ADMINISTRATIVE ACTIONS I-1

PROJECT LOCATION, HISTORY AND STATUS I-2

COMINCO AND NANA OBJECTIVES I-6

SCOPING ISSUES I-6

FEDERAL, STATE AND MUNICIPAL PERMITTING REQUIREMENTS . . I-8

COOPERATING AGENCY I-10

II. THE PROPOSED PROJECT

INTRODUCTION II-1

PROJECT COMPONENTS AND OPTIONS II-1
- Mine II-2
- Tailings Pond II-6
- Mill II-6
- Wastewater Treatment Plant II-12
- Worker Housing II-12

TABLE OF CONTENTS
(Continued)

II. THE PROPOSED PROJECT (Continued) Page

Water Supply II-12
Power Generation II-13
Transportation Corridor II-13
Road Transportation System II-16
Port Site II-19
Transfer Facility II-30
Fuel Storage II-32

DEVELOPMENT SCHEDULE II-33

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION

INTRODUCTION III-1

OPTIONS INITIALLY CONSIDERED III-1
Tailings Pond III-3
Worker Housing Type III-3
Water Supply III-3
Power Generation III-3
Transportation Corridor Location III-3
Transportation System III-7
Port Site Locations III-8
Transfer Facility III-8

OPTIONS SCREENING PROCESS III-8
Initial Options Evaluation III-8
Remaining Options Evaluation III-9
Transportation Corridor Identification III-35

IDENTIFICATION AND DESCRIPTION OF ALTERNATIVES III-39
Alternative 1 . . . . III-39
Alternative 2 . . . . III-39

TABLE OF CONTENTS
(Continued)

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION (Cont.) Page

Alternative 3 . . . . III-41
No Action Alternative III-41

COMPARISON OF ALTERNATIVES III-41

IDENTIFICATION OF PREFERRED ALTERNATIVE III-50

IV. AFFECTED ENVIRONMENT

INTRODUCTION IV-1

HISTORY IV-1

LAND STATUS IV-2

AFFECTED ENVIRONMENT IV-4
Geology, Physiography and Soils IV-4
Geology IV-4
Seismology IV-5
Physiography IV-5
Floodplains IV-7
Soils IV-8
Permafrost IV-8
Mineral Resources IV-8
Vegetation and Wetlands IV-8
Vegetation Type Descriptions IV-9
Wetlands IV-10
Threatened or Endangered Species IV-11
Terrestrial Wildlife IV-11
Birds IV-11
Mammals IV-12
Threatened or Endangered Species IV-17
Groundwater Resources IV-17

TABLE OF CONTENTS
(Continued)

IV. AFFECTED ENVIRONMENT (Continued) Page

Freshwater Resources IV-19
  Hydrology IV-19
  Water Quality IV-22
  Biology IV-30
Marine Biology IV-37
  Marine Invertebrates IV-38
  Marine Fish IV-40
  Marine Birds and Mammals IV-42
  Threatened or Endangered Species IV-43
Physical and Chemical Oceanography IV-44
  Currents/Circulation IV-44
  Wind and Wave Climate IV-44
  Coastal Geologic Processes IV-46
  Marine Water Quality IV-46
  Ice Conditions IV-47
Meteorology and Air Quality IV-47
  Meteorology IV-47
  Air Quality IV-49
Visual Resources IV-50
Sound IV-51
Cultural Resources IV-51
Subsistence IV-54
Socioeconomics IV-62
  Population IV-62
  Economy IV-65
  Community Facilities and Services IV-69
  Local and Regional Governance IV-70
Recreation IV-70
  Boating IV-71
  Hunting/Fishing IV-71
  Cape Krusenstern National Monument IV-72

TABLE OF CONTENTS
(Continued)

V. ENVIRONMENTAL CONSEQUENCES Page

INTRODUCTION V-1

COMPONENTS COMMON TO ALL ALTERNATIVES V-1
    Vegetation and Wetlands V-2
    Terrestrial Wildlife V-3
    Groundwater Resources V-4
    Freshwater Resources V-5
        Hydrology and Water Quality V-5
        Biology V-13
            Invertebrates V-13
            Fish V-14
    Air Quality V-17
    Visual Resources V-21
    Sound V-23
    Cultural Resources V-25
    Subsistence V-25
    Socioeconomics V-27
        Regional Employment and Income V-27
        Population Growth and Migration V-32
        Demand for Community Infrastructure V-34
        Social, Political and Cultural Stability and Autonomy V-34
    Recreation V-36

COMPONENTS SPECIFIC TO SOME ALTERNATIVES V-36
    Vegetation and Wetlands V-36
    Terrestrial Wildlife V-40
    Groundwater Resources V-45
    Freshwater Resources V-46
        Hydrology and Water Quality V-46
        Biology V-49
            Invertebrates V-49

TABLE OF CONTENTS

(Continued)

V. ENVIRONMENTAL CONSEQUENCES (Continued) Page

Fish V-50
Marine Biology V-52
Marine Invertebrates and Fish V-52
Marine Birds and Mammals V-55
Physical and Chemical Oceanography V-57
Coastal Geologic Processes V-57
Marine Water Quality V-59
Air Quality V-66
Visual Resources V-67
Sound V-68
Cultural Resources V-71
Subsistence V-72
Recreation V-74
Regional Use V-75
Technical Feasibility V-76
Cost V-77

NO ACTION ALTERNATIVE V-77

MITIGATION V-78

MONITORING V-81

RECLAMATION PLAN V-83

OTHER PROJECT IMPACTS V-86
Regional Impacts V-86
Increased General Public Access V-89
Cape Krusenstern National Monument Impacts V-91
Cumulative Impacts V-94

UNAVOIDABLE ADVERSE IMPACTS V-95

SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY V-95

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES V-96

SECTION 810, SUMMARY EVALUATION AND FINDINGS V-97

TABLE OF CONTENTS
(Continued)

VI. SUMMARY OF PERMIT AND REGULATORY PROGRAMS — Page

INTRODUCTION VI-1
FEDERAL APPROVALS VI-1
STATE APPROVALS VI-8
LOCAL APPROVALS VI-11

VII. CONSULTATION AND COORDINATION VII-1

VIII. LIST OF PREPARERS VIII-1

IX. EIS DISTRIBUTION LIST IX-1

X. PUBLIC RESPONSE TO DEIS X-1

XI. REFERENCES CITED XI-1

XII. GLOSSARY OF TECHNICAL TERMS, ACRONYMS AND ABBREVIATIONS AND MEASUREMENT EQUIVALENTS XII-1

XIII. INDEX XIII-1

TABLE OF CONTENTS

(Continued)

XIV. LIST OF APPENDICES

APPENDIX 1. RECLAMATION PLAN

APPENDIX 2. SPILL PREVENTION, CONTROL AND COUNTERMEASURE (SPCC) PLAN

APPENDIX 3. ENDANGERED SPECIES BIOLOGICAL ASSESSMENT

APPENDIX 4. NPDES DRAFT PERMIT

APPENDIX 5. DEPARTMENT OF ARMY PUBLIC NOTICE AND SECTION 404(b)(1) EVALUATION

APPENDIX 6. ANILCA TITLE XI RIGHT-OF-WAY APPLICATION

APPENDIX 7. PROTECTION OF CULTURAL RESOURCES

LIST OF TABLES

Table Page

II-1 Concentrate Production Schedule II-2

II-2 Red Dog Concentrator Reagents II-10

II-3 Preliminary Borrow Site Specifications, Southern Corridor II-25

II-4 Preliminary Borrow Site Specifications If All Borrow Material Was Taken From Outside Cape Krusenstern National Monument II-26

III-1 Component Options And Suboptions Identified During The Scoping Process III-2

III-2 Distances For Transportation Corridor Options And Suboptions III-6

III-3 Major Reasons For Elimination Of Individual Options And Suboptions During Initial Options Review III-10

III-4 Options And Suboptions Eliminated Or Retained For Further Analysis During Initial Options Review III-12

III-5 Individual Discipline Options Screening Criteria III-13

III-6 Summary Of Options Screening Criteria Analyses Showing Relative Levels Of Potential Impact . III-17

III-7 Grouped Relative Levels Of Potential Impact For Individual Disciplines III-31

III-8 Overall Relative Levels Of Potential Impact . . III-34

III-9 Options Used To Form Alternatives III-36

III-10 Evaluation Criteria Matrix Showing Relative Total Impact Values Assigned To The Three Action Alternatives III-42

IV-1 Mean Annual Flow Data For Some Streams In The Red Dog Mine Project Area IV-21

IV-2 Typical Mean Monthly Flow Proportions For Red Dog Project Study Area Streams IV-22

IV-3 Ten- And 100-Year Recurrence Flood Flows For Stream Locations In Red Dog Valley IV-23

IV-4 Seasonal Flows And Concentrations And Loads Of Zinc In Project Area Streams IV-26

IV-5 Seasonal Flows And Concentrations And Loads Of Lead In Project Area Streams IV-27

LIST OF TABLES
(Continued)

Table		Page
IV-6	Seasonal Flows And Concentrations And Loads Of Cadmium In Project Area Streams	IV-28
IV-7	Results Of Aerial Survey Counts For Overwintering Arctic Char In The Wulik And Kivalina Rivers, 1968 to 1982	IV-33
IV-8	Summary Of Number Of Fish Counted In ADF&G Arctic Char Spawning Surveys, 1981 to 1983 . .	IV-34
IV-9	Numbers And Percent Occurrence Of Marine Fish Species Collected During Summer 1982 By Various Gear Types	IV-41
IV-10	Percent Occurrence Of High Winds And Associated Storm Waves (Not Including Swell) At The Port Sites	IV-45
IV-11	NANA Region Household Dependency On Subsistence Harvest, Percent Distribution	IV-55
IV-12	Subsistence Resources Harvested For Kivalina And Noatak, 1972	IV-59
IV-13	Population Trends, 1960 To 1982, Study Area Communities	IV-63
IV-14	Distribution of Population, By Age And Sex, Kobuk Census Division, 1980	IV-64
IV-15	Baseline Population Forecast, NANA Region, 1982 To 2010	IV-65
IV-16	Distribution Of Employment, Kobuk Census Division, 1970 & 1980	IV-67
IV-17	Sources of Personal Income, By Sector, Kobuk Census Division, 1970 & 1980	IV-68
IV-18	Personal Income, By Source, Kobuk Census Division, 1970 & 1980	IV-69
V-1	Tailings Pond Water Balance	V-6
V-2	Treated Water Quality Projections	V-7
V-3	Tailings Pond Water Quality Projections (Assuming Complete Mixing)	V-10

LIST OF TABLES

(Continued)

Table Page

V-4 National Ambient Air Quality Standards (NAAQS), Estimated Prevention Of Significant Deterioration Increments, And Worst Case Projected Concentrations V-18

V-5 EPA Significant Emissions Rates V-19

V-6 Estimated Sources And Amounts Of Emissions From Project Components V-20

V-7 Estimated Sound Levels Generated By Mine Area Equipment And Facilities V-24

V-8 Average Annual Employment By Occupational Group V-28

V-9 Estimated Total Resident Employment Impacts, NANA Region V-30

V-10 Projected Annual Personal Income V-31

V-11 Projected Population Impact, NANA Region V-32

V-12 Estimated Population-Base Case And Impact Case, NANA Region V-33

V-13 Approximate Area Of Vegetation Types Intersected By Roads In The Transportation Corridors . . . V-37

V-14 Estimated Number And Type Of Stream Crossings Required For Southern And Northern Transportation Corridors V-48

V-15 Transfer And Shipping Frequency V-64

V-16 Estimated Road System And Port Facility Capital And Annual Operating Costs ($000) For Each Alternative V-78

VI-1 Major Federal, State And Local Permits, Contracts Or Other Approvals Required For Project Development VI-2

VII-1 Matrix Of Comments Received From Scoping Meetings And Written Responses VII-3

LIST OF FIGURES

Figure		Page
I-1	Northwestern Alaska	I-3
I-2	Red Dog Project Development Schedule	I-5
II-1	Red Dog Valley Map	II-3
II-2	Mine Pit Layout	II-5
II-3	South Fork Tailings Pond	II-7
II-4	Mill Site Facilities	II-9
II-5	Water Storage Reservoir	II-14
II-6	Red Dog Project Area	II-15
II-7	Typical Bridge & Culvert Crossings	II-17
II-8	Potential Borrow Sites Along Southern Corridor	II-18
II-9	Location of Potential Borrow Sites 1, 2 & 3	II-20
II-10	Location of Potential Borrow Sites 4, 5 & 6	II-21
II-11	Location of Potential Borrow Sites 7 & 8	II-22
II-12	Location of Potential Borrow Site 9	II-23
II-13	Location of Potential Borrow Sites 10, 11, 12, 13 & 14	II-24
II-14	Conceptual Diagram Of A Short Causeway/Lightering Transfer Facility	II-27
II-15	Conceptual Diagram Of A Short Causeway/Offshore Island Transfer Facility	II-28
II-16	Coastal Concentrate Storage Facility	II-29
II-17	Ballasted Tanker Transfer & Storage Facility	II-31
II-18	Conceptual Diagram of Construction Barge in Coastal Lagoon	II-34
III-1	Red Dog Valley Map Showing Tailings Pond Options	III-4
III-2	Red Dog Project Area Showing Transportation Route Options	III-5
III-3	Red Dog Project Alternatives	III-40
IV-1	Land Status In Project Area	IV-3
IV-2	Poor Soils in Project Area	IV-6

LIST OF FIGURES
(Continued)

Figure		Page
IV-3	Spring And Fall Waterfowl Staging Areas	IV-13
IV-4	Raptor Nest Sites In Project Area	IV-14
IV-5	Caribou Winter Range	IV-16
IV-6	Dall Sheep Range	IV-18
IV-7	Ikalukrok Creek Drainage Area Showing Existing Water Quality	IV-24
IV-8	Benthic Invertebrate & Fish Sampling Stations in Ikalukrok & Red Dog Drainages	IV-31
IV-9	Fish Occurrence in Project Area	IV-35
IV-10	Marine Benthic Infauna Sampling Stations	IV-39
IV-11	Visual Quality Objective Zones In Project Area .	IV-52
IV-12	Subsistence Use By Northwestern Alaska Native Villages	IV-56
IV-13	Annual Subsistence Activity Cycles, Upper And Lower Kobuk River Villages	IV-57
IV-14	Annual Subsistence Activity Cycles, Noatak And Kivalina Villages	IV-58
IV-15	Subsistence Use Areas, Kivalina Village	IV-60
IV-16	Subsistence Use Areas, Noatak Village	IV-61

INTRODUCTION

This introduction explains the requirement for an Environmental Impact Statement (EIS), the purpose of an EIS, and describes the process by which it is developed. It also explains how the EIS document is organized and how to effectively comment on the EIS.

WHY PREPARE AN EIS?

The National Environmental Policy Act (NEPA) of 1969 requires the preparation of an EIS whenever a proposed major federal action could significantly affect the quality of the human environment. In the case of the Red Dog project, the issuance of several major federal permits required before the project could proceed constitutes a set of major federal actions. These permits include the National Pollutant Discharge Elimination System (NPDES) Permit from the Environmental Protection Agency (EPA), and the Department of Army Permit from the U.S. Army Corps of Engineers (Corps). The NPDES Permit would authorize a wastewater discharge from the mining and milling operations. The Department of Army Permit would authorize dredging and filling operations within waters of the United States.

Additionally, Cominco has applied to the Department of the Interior (DOI) for permission to construct a mining access road through the northwest corner of Cape Krusenstern National Monument. This road would provide a means of transporting lead and zinc concentrates to a regional saltwater port on the Chukchi Sea. The process for authorizing construction of this transportation system, which includes the port and the road, is governed by Title XI of the Alaska National Interest Lands Conservation Act (ANILCA) of 1980. The Title XI process requires compliance with NEPA, as well as approvals from the President and Congress.

This EIS is therefore being written to fulfill the permitting requirements of EPA and the Corps as well as the EIS requirements of Title XI. EPA and DOI share the lead responsibility for preparing this document. The Corps is a cooperating agency. The NEPA regulations which outline the purpose, requirements and procedures for this EIS process may be found in the Code of Federal Regulations at 40 CFR Parts 1500 to 1508.

While the federal permitting actions require the preparation of an EIS, NEPA regulations also require that the EIS address, to the fullest extent possible, state and local planning requirements. This EIS therefore provides an information base which allows state and local agencies to begin addressing state right-of-way permit conditions, tideland lease stipulations and a number of other necessary permits (including state certification of the EPA and Corps permits). However, in several cases, the information necessary to fully address certain state and local permits has not yet been developed. These permits, which generally require detailed engineering information, will be sought after the location, size, etc., of the major project components have been determined by the EIS process.

HOW DOES THE EIS PROCESS WORK?

The primary purpose of the EIS process is to ensure that environmental information is available to public officials and citizens before permit decisions are made and before actions are taken. The process must encourage and facilitate public involvement in the decisions affecting the quality of the human environment. "Scoping" is the first step of the EIS process.

The purpose of this scoping process is to provide the opportunity for members of the public, interest groups and agencies to assist in defining the significant environmental issues related to the proposed project. For the Red Dog project, examples of these issues include water quality, fisheries, subsistence and impacts on Cape Krusenstern National Monument. Once these specific issues are identified, they are described in a document called the Responsiveness Summary that is distributed to all interested agencies and parties. These issues form the primary basis for determining the range of alternatives considered in the EIS.

Following scoping, the lead agency or agencies must ensure that sufficient environmental information is available to adequately address the significant issues raised during the scoping process. Alternative means of achieving the proposed project's objectives are developed and the environmental impacts are studied and compared. Finally, the EIS document is prepared and distributed to the public in draft form (DEIS) for a minimum of 45 days for formal review. During this period, public hearings or meetings are held to discuss the DEIS and to receive comments. Written comments may also be submitted, and they are encouraged.

Following public review of the DEIS, comments are evaluated and the DEIS changed accordingly. All written comments received during the review period are actually reproduced in the final EIS (FEIS), and the points raised are individually addressed in that document. The FEIS is then distributed for another public review period of at least 30 days before any decisions about the project can be implemented. This is to allow for additional public comments on the FEIS.

Once a permit decision has been made, a formal public record of decision is prepared by each permitting federal agency. The Record of Decision (ROD) states what major permit decision was made, identifies all alternatives considered including those considered environmentally preferable, and may discuss preferences among alternatives based on factors such as economic, technical, national policy and agency mission considerations. The ROD also states what mitigation, monitoring, and other means to avoid or minimize environmental harm were adopted, and if not, why they were not.

EIS DOCUMENT STRUCTURE

The format for an EIS is prescribed by the NEPA regulations. Each section has a specific purpose and often is required to include certain kinds of information. Following is a brief description of the major sections of an EIS.

- Summary - An adequate and accurate summarization of the EIS stressing major conclusions, areas of controversy, and the issues to be resolved.

- Purpose of and Need for Action - This chapter (I) specifies the underlying purpose of the action for which the EIS is being written, and why the action is needed.

- The Proposed Project - This chapter (II) describes the individual components of the project (e.g., mine, mill, power source, transportation system) and the specific options being considered for each component. It tells how the project will be developed.

- Alternatives Including the Proposed Action - This chapter (III) is the heart of the EIS. It describes all the initial options that were considered for the project, why many of them were eliminated, and how the final options and alternatives were selected. Then, based on the information and analyses presented in the chapters that follow on Affected Environment (IV) and Environmental Consequences (V), this chapter presents the environmental impacts of the proposed project alternatives in comparative form, thus sharply defining the issues and providing a clear basis for choice by the decision-makers and the public. It also identifies and describes the preferred alternative.

- Affected Environment - This chapter (IV) succinctly describes the existing environment of the area which would be affected by development of the project. It explains what the environment is like now, before project development begins.

- Environmental Consequences - This chapter (V) forms the scientific and analytic basis for the comparison of alternatives in Chapter III. It details the potential environmental impacts which could be expected for each alternative considering the mitigation, monitoring and reclamation procedures which would be used. In addition, it describes unavoidable impacts; discusses any irreversible or irretrievable commitments of resources; and describes the relationship between short-term and long-term productivity.

- Summary of Permit and Regulatory Programs - This chapter (VI) briefly describes the major federal, state and local permits, contracts and other approvals required for project development, and discusses how the EIS incorporates the relevant information to assist agencies in their permitting decisions.

- Consultation and Coordination - This chapter (VII) describes the process for soliciting input from agencies and the public, and how the process was coordinated with the agencies' permitting processes.
- Public Response to the DEIS - In the FEIS this chapter (X) will include a response to comments received during the DEIS review, both at public hearings and as written comments. Response will indicate how the final document was changed or why no changes were made.
- Appendices - This section incorporates important supplementary material prepared in connection with the EIS which is more appropriately presented separately from the body of the document.

Note that several words in the text are followed by an "*". These are technical terms which are defined in the Glossary (Chapter XII). The Glossary also contains acronyms, abbreviations and measurement equivalents.

HOW TO COMMENT ON THE DEIS

Comments on the DEIS may be made verbally at the public meetings or hearings, and/or in writing. Written comments are encouraged, and will ensure a specific, individual response in the FEIS. They need not be typed, but must be legible.

Comments may address any aspect of the DEIS, but it is important that comments be as specific as possible. Broad or vague statements about inadequacy of the DEIS will have little impact unless accompanied by specifics. Criticism of the adequacy of data or methodology should be accompanied by citations of additional data sources or of an alternative methodology and why it is better. When criticisms are made concerning environmental impacts, mitigation measures that might alleviate such impacts should be suggested. Too often valid concerns about an EIS are not clearly stated, and are misunderstood or ignored because they are obscured by generalizations.

I. PURPOSE OF AND NEED FOR ACTION

INTRODUCTION

Under the terms of the National Environmental Policy Act of 1969 (NEPA), all federal agencies must build into their decision-making processes ways both to consider the environmental effects of proposed actions and to minimize the adverse impacts of those actions. The Environmental Impact Statement (EIS) required by Section 102(2)(c) of NEPA is the action-forcing mechanism to accomplish those tasks.

DESCRIPTION OF PROPOSED ADMINISTRATIVE ACTIONS

The U.S. Environmental Protection Agency (EPA) has been considering the issuance of a New Source National Pollutant Discharge Elimination System (NPDES) Permit for wastewater discharge from the proposed Red Dog Mining Project in northwest Alaska. Also, the U.S. National Park Service (NPS) has been considering the issuance of a right-of-way permit for a road corridor across Cape Krusenstern National Monument for the same project. The issuance of either of these permits would be a type of federal action which is subject to NEPA. Pursuant to NEPA, and implementing regulations issued by the Council on Environmental Quality (CEQ), EPA and the U.S. Department of the Interior (DOI), this Draft EIS (DEIS) has been prepared to evaluate the potential impacts of the proposed actions on the environment.

EPA's NPDES regulations [40 CFR 122.29(c)(2)] require that the EIS include a recommendation on whether the NPDES Permit should be issued, denied or issued with conditions, and further, require that such action shall occur only after a complete evaluation of the projected impacts and recommendations contained in the Final EIS (FEIS).

Pursuant to Title XI* of the Alaska National Interest Lands Conservation Act of 1980 (ANILCA), the NPS is required to evaluate the proposed transportation system across Cape Krusenstern National Monument, and to determine whether it is compatible with the purposes for which the Monument was established and whether there is any economically feasible and prudent alternative route for the system.

In addition, the U.S. Department of the Army Corps of Engineers (Corps), Alaska District, has exerted jurisdiction over this action under Section 10 of the River and Harbor Act of 1899 which provides for control over structures or work in or affecting navigable waters of the U.S.; and under Section 404 of the Clean Water Act of 1972 which provides for regulation of the discharge of dredged or fill material into U.S. waters, including wetlands. Action by the Corps could be issuance of the permits, or issuance of the permits with stipulations. The Corps intends to adopt this document to fulfill its NEPA obligations if its concerns are satisfied in the FEIS.

---

* Defined in Glossary.

The 60-day review and comment period for this DEIS begins when the Notice appears in the Federal Register announcing the availability of this DEIS.

PROJECT LOCATION, HISTORY AND STATUS

Cominco Alaska, Inc. proposes to develop the Red Dog mineral prospect on Red Dog Creek, just west of Deadlock Mountain in the De Long Mountains of the Western Brooks Range (Fig. I-1). The site is located approximately 131 km (82 mi) north of Kotzebue, 55 km (34 mi) north of Noatak, 89 km (55 mi) east-northeast of the Chukchi Sea at Kivalina, and 161 km (100 mi) southeast of Cape Lisburne. It is 168 km (105 mi) north of the Arctic Circle.

The project would consist of an open pit lead/zinc mine, mill, diesel power generators, tailings pond*, housing and water supply facilities. All of these facilities would be located on private lands owned by the NANA Regional Corporation which are part of a selection of at least 8,975 ha (22,176 ac) in the Red Dog Valley. The mine area facilities would be connected by a road corridor to a port and shipping facilities located at the coast. The proposed mine contains approximately 77 million Mg (85 million tons) of ore and the expected mine life is at least 40 years.

Passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971 called for the evaluation of the resource potential of lands considered for possible inclusion in various national conservation systems. One of the areas of study was the De Long Mountains. In September 1975 the U.S. Bureau of Mines issued a press release outlining the findings of its work in that area. This press release spurred considerable interest from the mining industry. In the years to follow, two major exploration efforts, one by Cominco and the other by GCO Minerals Company, resulted in the staking of some 18,000 claims in the area to the west and southwest of the Red Dog prospect. The NANA Regional Corporation obtained selection rights to the Red Dog area with the passage of ANILCA in 1980.

After the establishment of its right to the Red Dog deposit, NANA sought a partner to aid in development of the project. After discussing the project with a number of mining companies, NANA selected Cominco as its partner. In the spring of 1982, a letter of agreement was signed which outlined the relationship between Cominco and NANA. That agreement called for Cominco to lease the property from NANA and to act as operator of the project. Cominco would be responsible for permit acquisition, design, construction, financing and operation of the mine. NANA would receive 50 percent of the net profits of the project over time.

---

* Defined in Glossary.

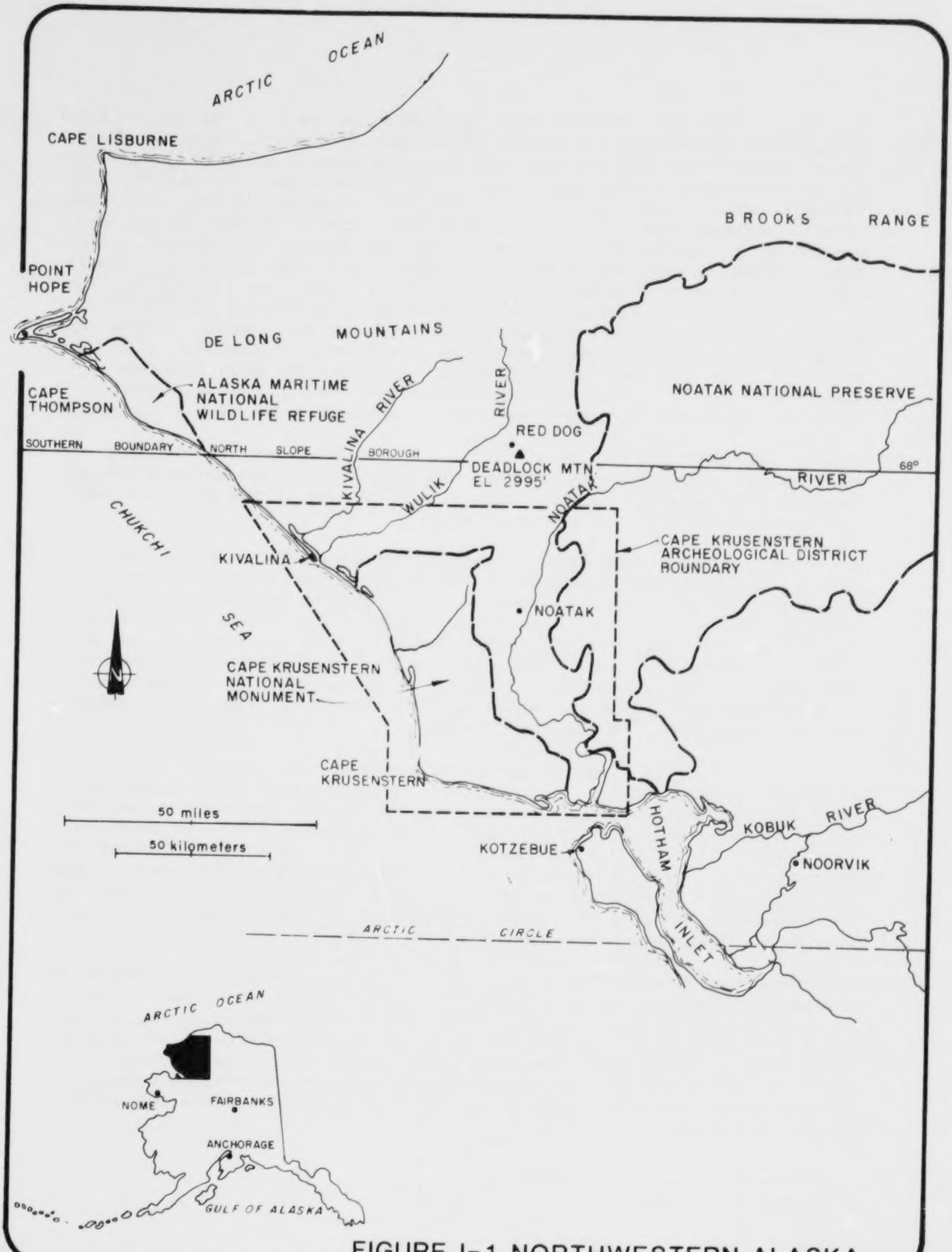

ARCTIC OCEAN
CAPE LISBURNE
BROOKS RANGE
POINT HOPE
DE LONG MOUNTAINS
CAPE THOMPSON
ALASKA MARITIME NATIONAL WILDLIFE REFUGE
KIVALINA RIVER
RIVER
NOATAK NATIONAL PRESERVE
RED DOG
SOUTHERN BOUNDARY NORTH SLOPE BOROUGH
DEADLOCK MTN. EL 2995'
RIVER
68°
WULIK
NOATAK
CHUKCHI SEA
CAPE KRUSENSTERN ARCHEOLOGICAL DISTRICT BOUNDARY
KIVALINA
NOATAK
CAPE KRUSENSTERN NATIONAL MONUMENT
N
CAPE KRUSENSTERN
50 miles
50 kilometers
HOTHAM INLET
KOBUK RIVER
KOTZEBUE
NOORVIK
ARCTIC CIRCLE
ARCTIC OCEAN
NOME
FAIRBANKS
ANCHORAGE
GULF OF ALASKA

FIGURE I-1 NORTHWESTERN ALASKA

In August 1982 GCO Minerals made application to the U.S. Bureau of Land Management (BLM) and the Alaska Department of Natural Resources (DNR) for a transportation right-of-way from their Lik mineral prospect (only 19 km [12 mi] northwest of Red Dog Valley) to the Chukchi Sea. In January 1983, Cominco formally made application to EPA for an NPDES Permit. EPA then made a determination under NEPA that its issuance of that permit would constitute a significant action affecting the human environment. This determination formally began the EIS process, with EPA as the lead federal agency. Ott Water Engineers, Inc. of Anchorage was then selected by EPA, in consultation with Cominco, as the third party contractor to prepare the EIS for EPA. Faced with two similar right-of-way applications, federal and state agencies decided that only one transportation corridor would be approved, and that only one EIS would be written for both applications to select that route. After further discussions among the applicants and agencies, GCO Minerals requested that its application be held in abeyance.

During February and March of 1983 an EIS scoping process identified the major issues associated with the Red Dog project. In late spring Cominco's baseline data collection program, which was initiated in the spring of 1981, was extended through the summer of 1983.

As the EIS process progressed, the possibility emerged that a transportation corridor through Cape Krusenstern National Monument might be selected as the preferred alternative. Cominco then began to explore with NPS the ANILCA Title XI process for securing a right-of-way across the Monument. On November 7, 1983 Cominco made a formal Title XI application to the NPS. Cominco's application is the first ever filed. At that point, DOI became co-lead agency with EPA for the EIS process in accordance with the Memorandum of Agreement among EPA and the cooperating agencies. Title XI applications were also filed with EPA and the Corps.

In June 1983 NANA began separate discussions with the NPS for a land exchange. This exchange, if successfully negotiated and implemented, would alter the northwest boundary of the Monument to exclude lands surrounding the preferred transportation corridor, thereby making a Title XI permit unnecessary. The NPS would receive NANA lands for inclusion within the Monument, as well as other lands and interests outside the Monument. Land exchange discussions are expected to continue throughout the EIS and Title XI processes. If the preferred alternative was developed with a land exchange, the environmental impacts would be similar.

Cominco's most probable schedule (Fig. I-2) shows the winter of 1985-86 as the beginning of construction. The construction period would last a minimum of 24 months with mining beginning in 1988. The actual beginning of construction would depend on world economic conditions, ability to complete detailed engineering design, and the progress of the environmental permit process. In the event that any delays in the schedule occurred, the necessity to meet annual sealift* windows would require modification in the construction period by one year increments.

---

* Defined in Glossary.

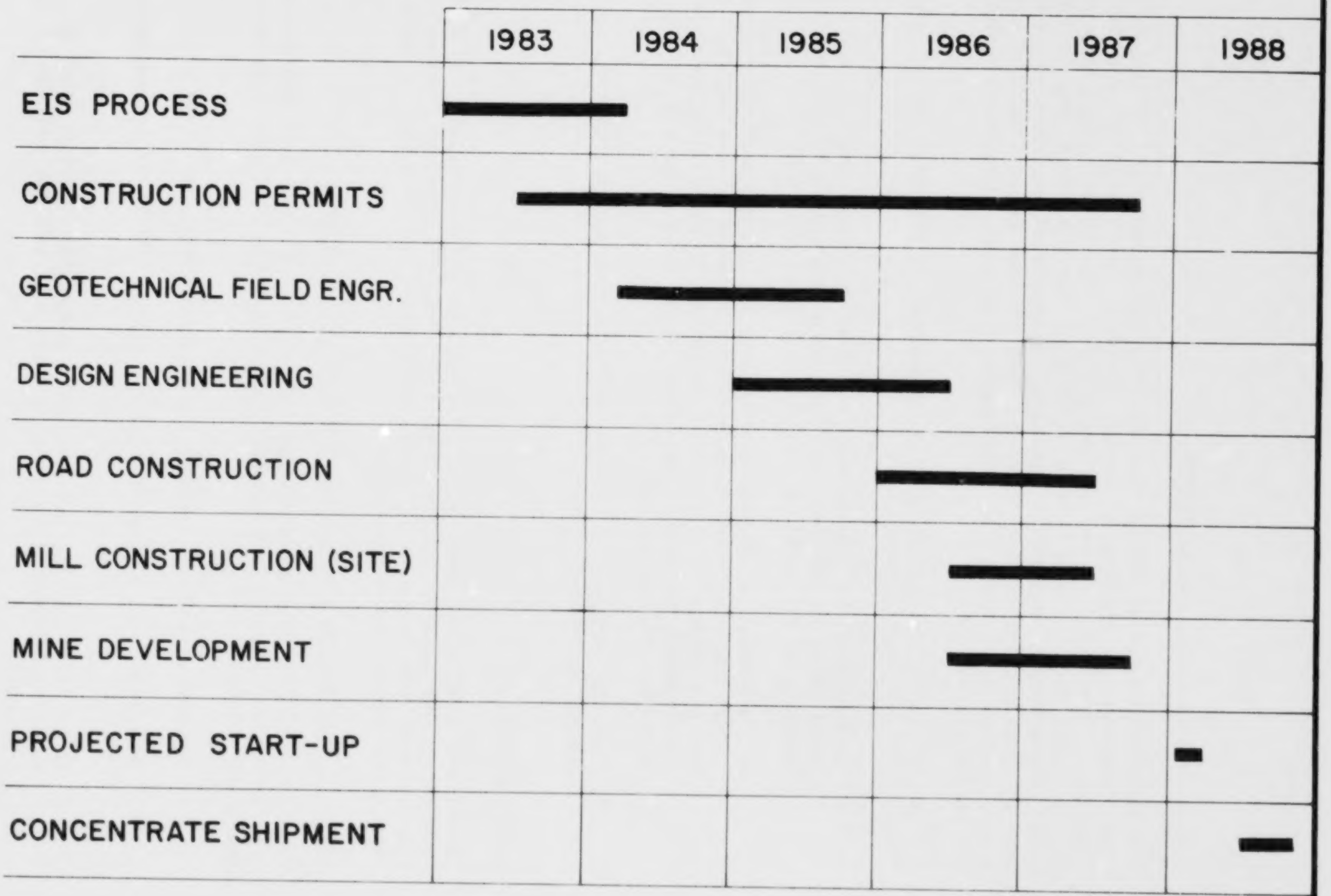


FIGURE I-2 RED DOG PROJECT DEVELOPMENT SCHEDULE

COMINCO AND NANA OBJECTIVES

The agreement between NANA and Cominco for development of the Red Dog mine represents a melding of social, cultural, environmental and economic interests. The intent of the agreement is to allow development in a manner that provides for: a long-term economic base for the NANA region; jobs for NANA shareholders and other Alaskans; a source of lead/zinc concentrates and an economic return for Cominco; and minimal impacts on the region's social, historical, cultural and subsistence lifestyles. Important features of the agreement include:

- A rate of production jointly determined to maximize life of the mine and economic return.
- Development of "temporary" facilities to house workers on a rotational basis to eliminate the long-term disruptive influence of a new townsite on the existing village lifestyle of the region.
- A commitment to develop and operate the project with careful consideration for the existing subsistence lifestyle of the region. NANA has the authority to suspend operations if the project were to have too negative an effect upon subsistence (e.g., during caribou, fish or marine mammal migrations).
- Complete reclamation of the area, to the extent feasible, following completion of the project.

SCOPING ISSUES

During the scoping process, which involved the full participation of Cominco, members of the public, special interest groups, and agencies involved in the EIS process, the following 12 issues were identified as being of major concern if the project were developed:

Issue 1: Maintaining the Quality and Quantity of Water

The project has the potential for both enhancement and degradation of freshwater resources in the project area. Potential problems associated with the project include:

- Increased sediment loads in watercourses from disturbed areas.
- Alteration of streamflow which could affect fish movements and habitat.
- Degradation of surface and/or groundwater through mine drainage, heavy metal and trace element leachates, and the addition of reagent chemicals.

Issue 2: Maintaining the Quality and Quantity of Fishery Habitat, and Minimizing Disruption of Fish Movements

Construction of an overland transportation system and a port site has the potential to disturb fish movements, spawning, and rearing habitats. Failure to meet water quality criteria at the mine could also adversely affect fishery resources.

Issue 3: Maintaining the Quality and Quantity of Wildlife Habitat, and Minimizing Impacts on Wildlife

Development of several project components, particularly the overland transportation system and the port site, has the potential to impact wildlife and wildlife habitats. Specific concerns include:

- Direct habitat loss due to physical change.
- Indirect habitat loss due to increased activity and human disturbance.
- Alteration of traditional movement patterns (e.g., caribou).

Issue 4: Minimizing Impacts on Coastal Geologic Processes

Development of a port site and concentrate shipping facilities has the potential to disturb natural sediment processes (e.g., longshore gravel transport). Such disturbance might affect the integrity of coastal lagoons and could conceivably affect the archeologically significant beach ridges at Cape Krusenstern.

Issue 5: Minimizing Impacts on Marine Life

Construction and operation of a port site with fuel and concentrate loading facilities and shipping activity could directly impact or cause the relocation of marine species.

Issue 6: Protecting Subsistence Resources and Their Use

Construction and operation of the project could impact subsistence resources and their use by residents of the nearby communities of Kivalina and Noatak. Of particular concern are caribou, Arctic char, waterfowl and marine mammals.

Issue 7: Protecting Cultural Resources

The project would be constructed and operated in an area of important archeological resources as evidenced by the creation of Cape Krusenstern National Monument around the significant archeological values of the Cape Krusenstern beach ridges.

Issue 8: Minimizing the Social, Cultural and Economic Impacts on Residents of the Region

Development of a large mining project in an otherwise rural area of northwestern Alaska would have impacts upon the social, cultural and economic lifestyles of the region's residents.

Issue 9: Designing Project Components from a Regional Use Perspective

The design of several project components, particularly the port site and transportation corridor, would significantly influence the future development of the western De Long Mountains region of northwest Alaska. DNR has indicated that they will permit only one, multi-use transportation corridor through the region, so the siting and design of these components should be made from a regional use perspective.

Issue 10: Impacts on Cape Krusenstern National Monument

Since some feasible transportation corridor options pass through Cape Krusenstern National Monument, impacts on the Monument would have to be evaluated. This issue could have national significance. While Title XI of ANILCA establishes a process for gaining access through the Monument, the act requires that there be no economically feasible and prudent alternative route for the system.

Issue 11: Technical Feasibility

If project components or mitigation and reclamation measures became too complex, an increased risk of failure could result, and technical feasibility would then become an issue.

Issue 12: Economic Feasibility

If costs of project components or mitigation and reclamation requirements exceeded reasonable or practical limits, economic feasibility would become an issue.

FEDERAL, STATE AND MUNICIPAL PERMITTING REQUIREMENTS

Before construction and operation of the Red Dog project could begin, Cominco must obtain several federal and state approvals. These are discussed in more detail in Chapter VI as they relate to the EIS process. Some of the major permits, contracts or other approvals include:

Federal Government

U.S. Environmental Protection Agency (EPA):

- National Pollutant Discharge Elimination System Permit (NPDES)
- Review of U.S. Army Corps of Engineers Section 404 Permit for conformance with Section 404(b)(1) guidelines
- Review of ANILCA Title XI Permit Application

U.S. Army Corps of Engineers (Corps):

- Department of the Army (DA) Permit under authority of Section 404 (discharge of dredged or fill material into U.S. waters, including wetlands)

- DA Permit under authority of Section 10 (any structure or activity affecting navigable waters of the U.S.)
- Review of transportation system under ANILCA Title XI

U.S. National Park Service (NPS):

- Right-of-way for transportation system under ANILCA Title XI (if Cape Krusenstern National Monument route was selected)
- ANILCA Section 810 Subsistence Compliance Findings

U.S. Fish and Wildlife Service (FWS):

- Possible Section 7 Consultation (for the endangered peregrine falcon)

National Marine Fisheries Service (NMFS):

- Possible Section 7 Consultation (for endangered marine mammals)

Advisory Council on Historic Preservation (ACHP)

- Consultation on Cultural Sites

State of Alaska

Department of Environmental Conservation (DEC):

- Air Quality Permit to Operate (including Prevention of Significant Deterioration [PSD] Permit approval)
- Certificate of Reasonable Assurance (Water Quality)
- Wastewater Disposal Permit
- Solid Waste Disposal Permit

Department of Fish & Game (ADF&G):

- Title 16 Anadromous* Fish Stream Permit

Department of Natural Resources (DNR):

- Right-of-Way Permit
- Water Rights Permit
- Dam Safety Permit
- Tidelands Use Permit
- Tidelands Lease
- Materials Sale Contract

---

* Defined in Glossary.

State Historic Preservation Office (SHPO):

- Cultural Resources Clearance on State Lands
- Consultation on Cultural Sites, Federal Lands

Governor's Office of Management and Budget, Division of Governmental Coordination:

- Coastal Zone Management Consistency Determination Concurrence

Local Government

North Slope Borough (NSB):

- Land Use Permit

COOPERATING AGENCY

In addition to the EPA and DOI as co-lead agencies, the Corps is a cooperating agency for the Red Dog EIS.

II. THE PROPOSED PROJECT

INTRODUCTION

Development of the Red Dog mining project would involve an open pit lead/zinc mine located 131 km (82 mi) north of Kotzebue. The ore would be crushed and the metallic sulfides concentrated in a mill near the mine site, with the concentrates transported to the coast for shipment to market. While the deposit has not yet been fully defined by geologists, at least 77 million Mg (85 million tons) of ore exist. The ore contains approximately 5.0 percent lead, 17.1 percent zinc, 75 g/Mg (2.4 oz/ton) silver and measurable levels of barite. The project has a potential life of at least 40 years under expected production rates, with the possibility of extension if additional ore is found. The mine would be developed in two phases. The "initial" phase of production would extend five years and produce approximately 434,450 Mg/yr (479,000 tons/yr) of concentrates (Table II-1). The "expanded" phase of production would extend from the sixth year of development through the life of the project. Approximately 683,878 Mg/yr (754,000 tons/yr) of concentrates would be produced during this phase (Table II-1).

The mine, tailings pond, mill, power plant, worker housing and water reservoir would all be located within a 8,975 ha (22,176 ac) parcel of private land owned by NANA in Red Dog Valley. The port site would also be on private NANA land if located at VABM 28, and probably on NANA land if located at Tugak Lagoon. The transportation corridor would be almost totally on public land.

PROJECT COMPONENTS AND OPTIONS

In reviewing this document, it is important that the reader understand the relationship among the terms "component", "option" and "alternative". The project has several components, each one a necessary part of an entire viable mining project (e.g., the mine, mill site, tailings pond, transportation system, port site, etc.). For each component there may be one or more options (e.g., a northern or a southern transportation corridor option). An alternative is a combination of options (one for each component) that constitutes an entire functioning project.

The EIS scoping process initially identified at least two, and often several, options for each component. The process by which this large number of options was screened to reduce the number to a manageable level, and the

Table II-1

CONCENTRATE PRODUCTION SCHEDULE

Daily Production (Average Amount/Day)	Initial Production Rate		Expanded Production Rate	
	Mg[1]	Tons	Mg[1]	Tons
Ore	2,721	3,000	5,079	5,600
Lead Concentrate	204	225	308	340
Zinc Concentrate	907	1,000	1,515	1,670
Barite Concentrate	127	140	127	140
Tailings*	1,678	1,850	2,766	3,050
Annual Production				
Ore	958,700	1,057,000	1,779,534	1,962,000
Lead Concentrate	71,650	79,000	107,933	119,000
Zinc Concentrate	317,450	350,000	530,595	585,000
Barite Concentrate	45,350	50,000	45,350	50,000
Tailings	524,250	578,000	1,095,656	1,208,000

[1] 1 Mg (megagram) = 1.102 tons
1 ton = 0.907 Mg

Source: Cominco Alaska, Inc.

ultimate project alternatives were selected, is described in detail in Chapter III. The following description of each project component, therefore, addresses only those component options which were ultimately retained and are specifically addressed in at least one of the three action alternatives.

Mine

The Red Dog deposit is located on a side hill on the main fork of Red Dog Creek. The immediate topography generally consists of rolling hills with wide valleys. The zone of mining influence would impact the main stem of Red Dog Creek (Fig. II-1).

---

* Defined in Glossary.

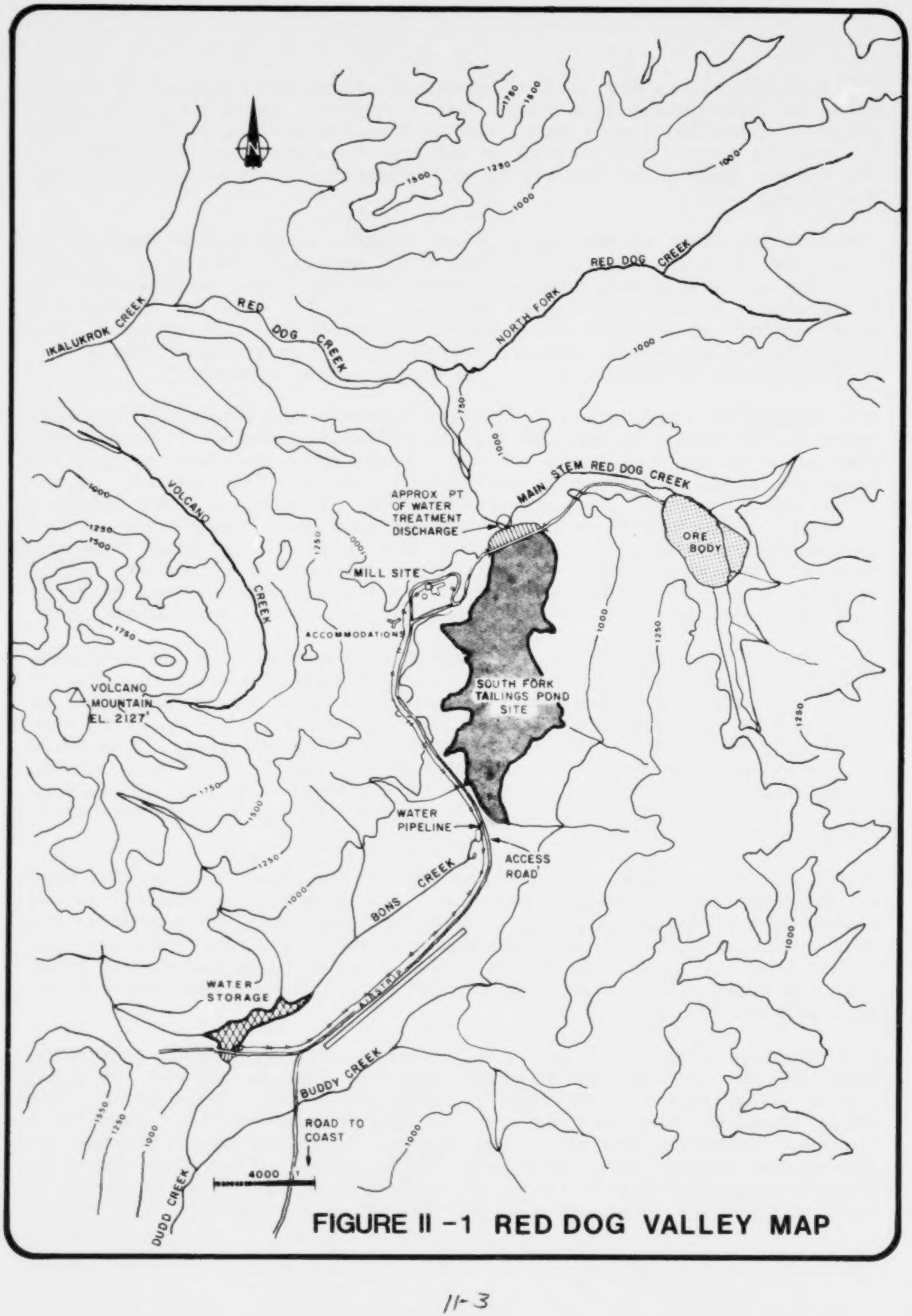

N
1750
1900
1500
1250
1000
IKALUKROK CREEK
RED DOG CREEK
NORTH FORK RED DOG CREEK
1000
750
1000
MAIN STEM RED DOG CREEK
APPROX PT OF WATER TREATMENT DISCHARGE
ORE BODY
VOLCANO CREEK
1000
1250
1500
1750
1250
1000
MILL SITE
ACCOMMODATIONS
1000
1250
SOUTH FORK TAILINGS POND SITE
VOLCANO MOUNTAIN EL. 2127'
1250
1750
1500
WATER PIPELINE
ACCESS ROAD
1250
1000
BONS CREEK
1000
WATER STORAGE
AIRSTRIP
BUDDY CREEK
1550
1250
1000
ROAD TO COAST
1000
4000 FT
DUDD CREEK

FIGURE II -1 RED DOG VALLEY MAP

The outcropping ore body and its geological configuration dictate that a conventional underground mine would not be feasible. Open pit mining would require overburden (waste rock) removal from the surface of the ore body, followed by drilling and blasting of the ore in benches within an open pit. Overburden material not suitable for mill processing would be stockpiled near the tailings pond.

The mine pit would be developed in two stages: preproduction followed by production mining. During preproduction, overburden would be removed from the pit, and access roads, pit ramps and the initial benches would be established. Unmineralized waste would be used for road and tailings dam construction. Mineralized waste would be stockpiled in a catchment area above the tailings pond. During preproduction, it is estimated that a total of 1,242,000 Mg (1,365,000 tons) of material would be removed.

Ore production rates are an important economic factor and are normally based on the extent of services and the estimated quantities of concentrates that would be accepted in the markets. Initial production mining would involve the annual extraction of 958,700 Mg (1,057,000 tons) of ore. On an initial operating basis, an average of 2,721 Mg (3,000 tons) of ore would be sent each day to the concentrator (mill) for upgrading (Table II-1). Drilled and blasted ore would be loaded into mine type trucks using front-end loaders. The mine trucks would transport the ore to a crushing facility adjacent to the mill. The same loaders and trucks would be used to transport low grade ore and waste materials to stockpiles at the tailings pond.

The open pit would be designed to optimize ore recovery with due consideration given to protection of the Red Dog Creek watershed adjacent to the pit area (Fig. II-2). Pit slopes would be designed at 35 degrees and would be confirmed by rock mechanics design. Benches would be 7.6 m (25 ft) high and access ramps 18.3 m (60 ft) wide at an eight percent grade. The initial pit would be approximately 244 m (800 ft) in diameter and could contain seven benches down to the 297 m (975 ft) elevation. The final pit could be 853 m x 305 m (2,800 ft x 1,000 ft) in area and contain up to 28 benches to the 152 m (500 ft) elevation.

A diversion ditch would be constructed between Red Dog Creek and the open pit to collect runoff from the mine area. The ditch would initially intercept runoff from an approximate area of 0.65 km^2 (0.25 mi^2). The depth of the ditch would be sufficient to ensure that it would collect most of the ore zone runoff from the south side of the creek. If significant subsurface inflow from the creek occurred, a seepage cutoff wall would be added where necessary to block this inflow.

The drainage ditch would also collect surface erosion sediment originating from the open pit and the associated ore haul road to the mill. A pump station would route runoff from the open pit to the tailings pond. The ditch, collection sump and pump to the tailings pond would be sized for a 10-year recurrence 24-hour storm event. Adequate capacity would be allowed for winter icings and snow accumulation. The ditch would be cleaned of ice and erosion debris, if necessary, in late winter or spring to retain capacity for spring breakup and summer storm runoff.

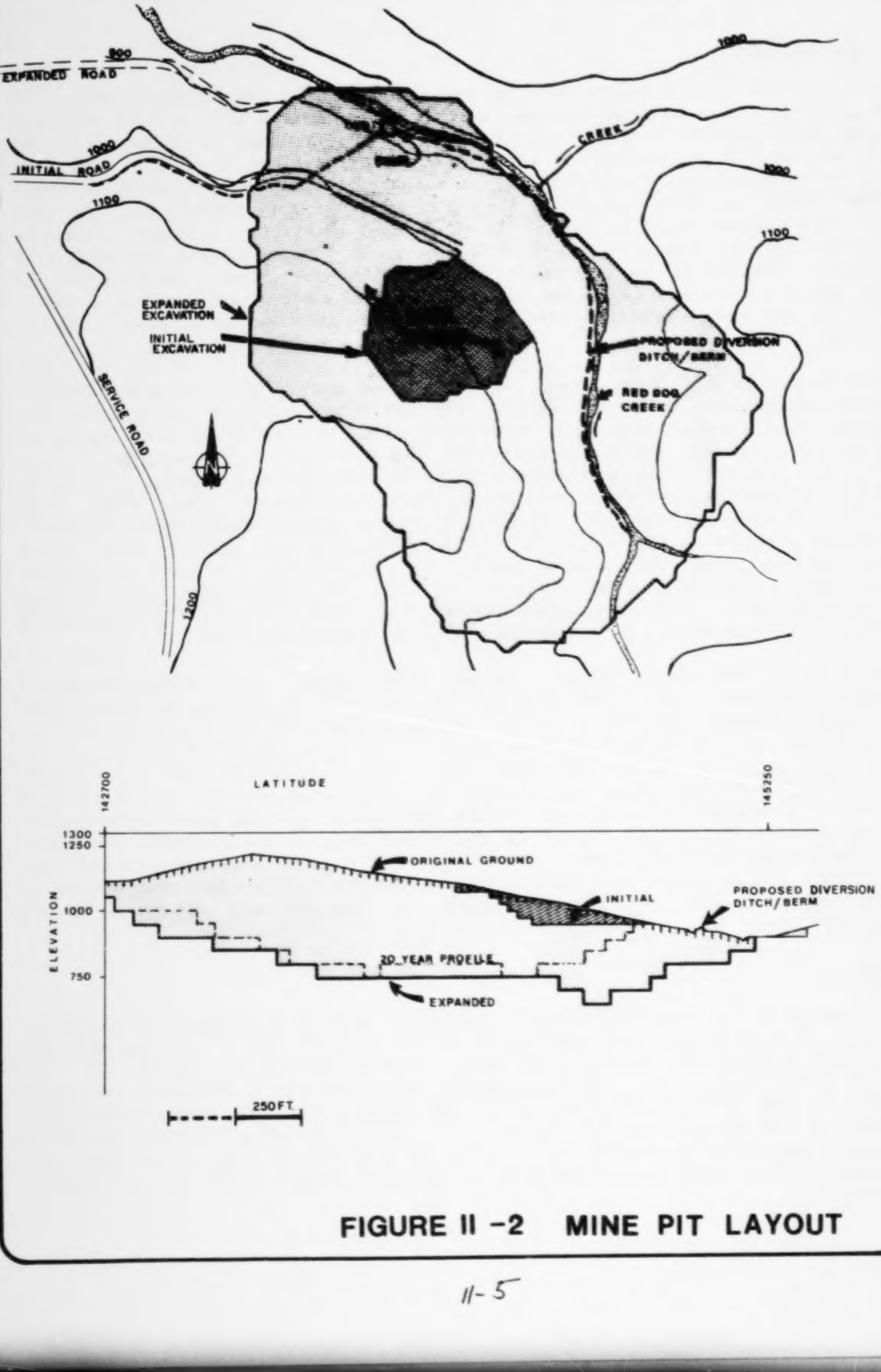

900
EXPANDED ROAD
1000
INITIAL ROAD
1100
CREEK
1000
1000
1100
EXPANDED EXCAVATION
INITIAL EXCAVATION
PROPOSED DIVERSION DITCH/BERM
RED DOG CREEK
SERVICE ROAD
N
1200
142700
LATITUDE
145250
1300
1250
1000
750
ELEVATION
ORIGINAL GROUND
INITIAL
PROPOSED DIVERSION DITCH/BERM
20 YEAR PROFILE
EXPANDED
250 FT.

FIGURE II -2 MINE PIT LAYOUT

Tailings Pond

The location of the South Fork tailings pond in Red Dog Valley is shown on Figure II-1. A detailed diagram of the approximately 237 ha (585 ac) tailings pond facility is shown on Figure II-3. The tailings pond dam would be in the form of an impervious earth-filled structure with a spillway designed to maintain structural integrity in the event of an overflow. The earth-filled dam would be constructed in stages. Prior to full production, the dam would be constructed to contain five years of production tailings. The dam would then be raised to its final elevation in stages during the next five years. The top of the dam would be used as a road to haul ore from the pit to the mill complex. The dam is designated to handle tailings from production of the known ore body which is presently identified as 77 million Mg (85 million tons) of ore.

Thickened tailings slurry from the mill concentrating process would contain about 60 percent solids by weight, with the liquid portion consisting of excess process water, dissolved minerals and perhaps some residual reagents. The slurry would flow by gravity from the mill into the tailings pond. An internal process using a thickener would be used to return water directly to the mill process circuit as a step in minimizing process water loss. It is estimated that approximately 85 percent of mill process water could be recirculated directly in the mill in this way. Additional mill process water would be recycled from the tailings pond (25 percent) or from the freshwater source (11 percent). These recycle estimates are based upon water balance flowsheet data (Cominco Engineering Services, Ltd., 1983b). Tailings in the form of a thickened pump would be deposited behind the dam.

Red Dog Creek tributaries with known metal content of toxic concentrations would continue to drain into the tailings pond for treatment, as would precipitation-related runoff. Diversion structures and ditches would be built to control or prevent excess surface drainage of uncontaminated water into the tailings pond. The surface water would be routed into the Bons Creek drainage, thus reducing the amount of water accumulating in the tailings pond. Chemical treatment and metals removal of tailings pond water would take place in a treatment plant prior to discharge to the presently minerals-contaminated Red Dog Creek. Discharges would occur only between May and October. A seepage contingency dam would be constructed downstream of the main tailings pond dam to collect any seepage and return it to the tailings pond.

Mill

Proximity to the mine and tailings pond were determining factors in mill location. The proposed mill site would be on a small hill of bedrock outcrop located opposite the ore body on the northwest side of the South Fork tailings pond (Fig. II-1). This site would be located within the pond catchment area so that tailings slurry could flow by gravity from the concentrator complex to the tailings pond. In addition, worker housing facilities would be located within a reasonable distance of the mill site so that waste heat produced in the power generation process could be used to heat the accommodations.

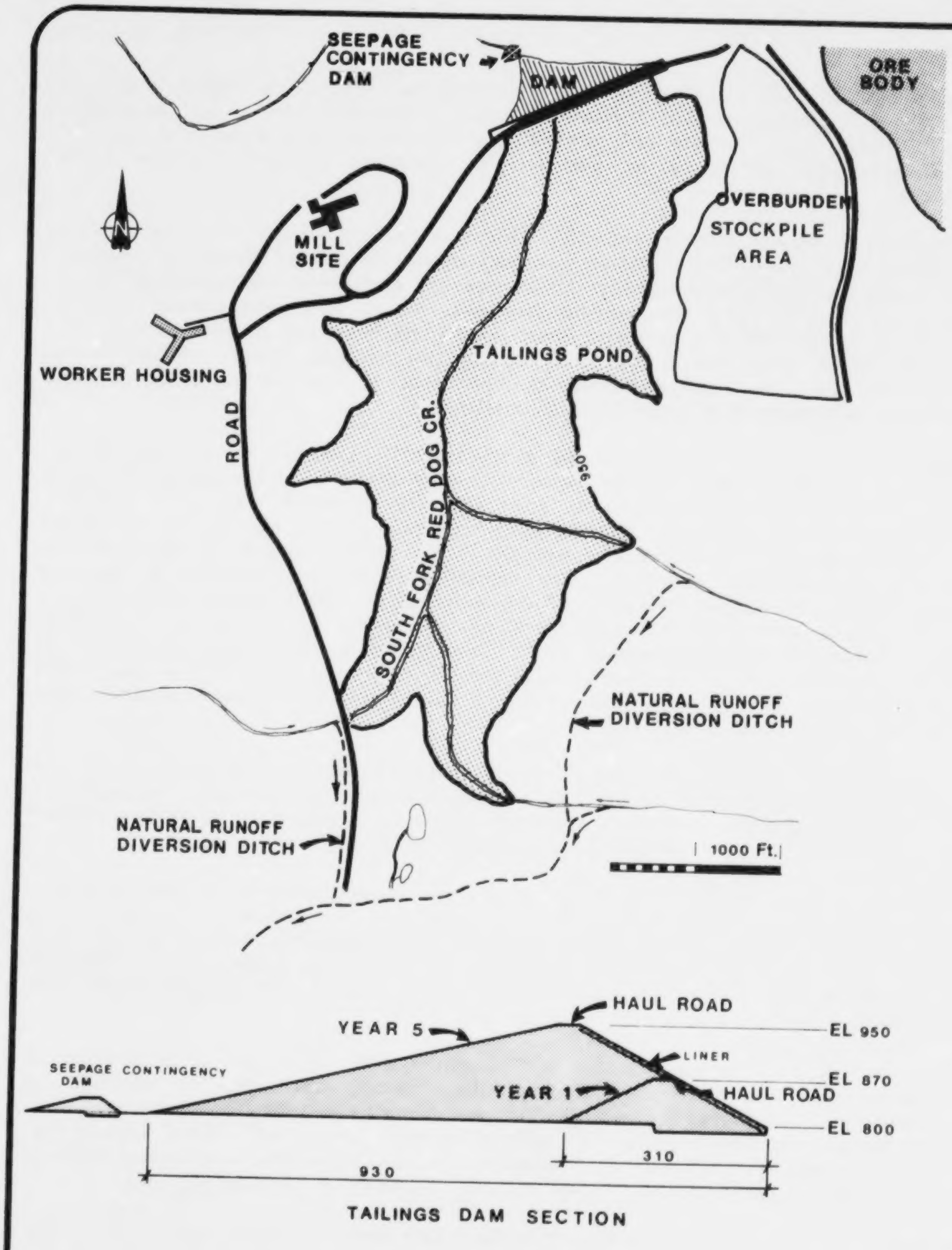

SEEPAGE CONTINGENCY DAM
DAM
ORE BODY
OVERBURDEN STOCKPILE AREA
MILL SITE
WORKER HOUSING
ROAD
TAILINGS POND
SOUTH FORK RED DOG CR.
950
NATURAL RUNOFF DIVERSION DITCH
NATURAL RUNOFF DIVERSION DITCH
1000 Ft.
HAUL ROAD
YEAR 5
EL 950
LINER
SEEPAGE CONTINGENCY DAM
YEAR 1
EL 870
HAUL ROAD
EL 800
310
930
TAILINGS DAM SECTION

FIGURE II -3 SOUTH FORK TAILINGS POND

The proposed mill complex is shown on Figure II-4. The approximately 14 ha (35 ac) complex would include a water treatment plant, a diesel-based power plant, fuel storage and distribution facilities, and a vehicle maintenance/warehouse structure in addition to facilities integral to the milling process.

The project would use a selective flotation milling process to concentrate valuable minerals. The flotation process would consist of three major steps: size reduction, selective mineral concentration and moisture reduction of the concentrates. During the milling process, lead, zinc and barite minerals would be separated and concentrated, while the residual tailings slurry containing waste rock would be directed to the tailings pond. Silver forms complexes with the lead and zinc concentrates in the milling process, and would be separated out later during smelting.

After grinding, the ore would be suspended in a water slurry and transported to flotation cells (tanks) where the valuable minerals would be separated from waste materials in a froth flotation process. In this process, valuable minerals adhere to air bubbles that rise to the surface of the tanks and are removed. To make the process work efficiently, it is necessary to add air and various reagents. The reagents either aid flotation of valuable components or suppress flotation of waste material. This allows the bubbling and frothing action to float different ore minerals selectively so that metal concentrates can be produced. The ore minerals would be separated as sulfide concentrates of lead and zinc, with barite recovered in the last stage of the process as barium sulfate. Waste would include silicate minerals and small concentrations of sulfides.

Following separation of the ore minerals from waste rock, dewatering of the concentrates would take place using lead and zinc thickeners, followed by filtration and thermal drying. Wherever possible, waste heat from the diesel-based power generation would be used for drying the concentrates.

No reduction of sulfides to base metals or other changes in the chemical composition of ore minerals would take place in the concentrator or at the project site. The upgraded lead and zinc concentrates (which would also contain silver) would be shipped to smelters outside of Alaska for processing to refined metals. Barite concentrate would be dried and bagged locally for possible use in formulating oil well drilling mud.

The mill would be a major consumer of water and, as such, recirculation of process water would be used to the fullest extent possible. In addition to concentrate thickeners, a tailings thickener would be used to recycle water, thus decreasing the volume of tailings slurry produced. This would decrease the amount of water that would have to be treated, and would reduce annual water demand by approximately 3,400 million ℓ (900 million gal).

Reagents are an integral part of mill operation and sufficient quantities for a year's operation would be stored at the mill site. Reagents to be used for the Red Dog project are shown in Table II-2. These materials would be supplied in annual shipments and stored in a secure area at the port site.

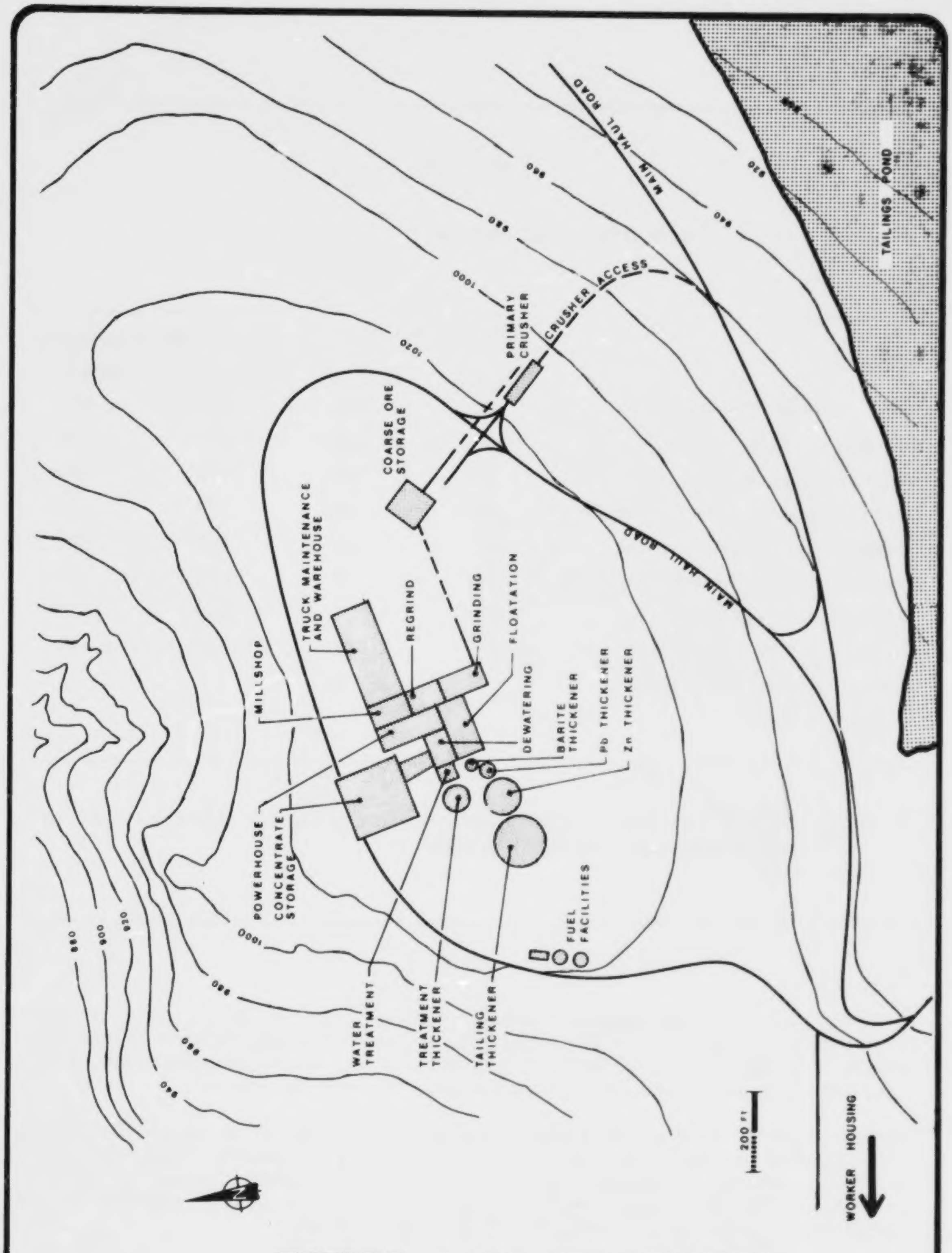

TAILINGS POND
MAIN HAUL ROAD
920
940
960
980
1000
1020
CRUSHER ACCESS
PRIMARY CRUSHER
COARSE ORE STORAGE
MAIN HAUL ROAD
TRUCK MAINTENANCE AND WAREHOUSE
REGRIND
GRINDING
FLOATATION
MILLSHOP
DEWATERING
BARITE THICKENER
Pb THICKENER
Zn THICKENER
POWERHOUSE
CONCENTRATE STORAGE
FUEL FACILITIES
WATER TREATMENT
TREATMENT THICKENER
TAILING THICKENER
880
900
920
1000
980
960
940
200 FT
WORKER HOUSING

FIGURE II -4 MILL SITE FACILITIES

Table II-2

RED DOG CONCENTRATOR REAGENTS

	Initial Production		Expanded Production	
	Mg/yr	tons/yr	Mg/yr	tons/yr
Zinc sulfate ($ZnSO_4$)	480	529	891	982
Copper sulfate ($CuSO_4$)	480	529	891	982
Sodium cyanide (NaCn)	96	106	179	197
Methylisobutyl carbinol (MIBC)	48	53	89	98
Sodium isopropyl xanthate	480	529	891	982
Sodium cetylsulfonate (EC-111)	72	79	72	79
Sulfuric acid (H_2SO_4)	959	1,057	1,780	1,962
Hydrated lime [$Ca(OH)_2$]*	2,396	2,642	5,845	6,443
Polyacrylamide flocculant* (Percol 730)	5	6	5	6

* Note: Part of the lime and all of the flocculant supply would be used in the wastewater treatment process.

The zinc ($ZnSO_4$) and copper ($CuSO_4$) sulfates used as conditioners in flotation would be handled in polylined and sealed palletized cartons of approximately 0.9 Mg (1 ton) capacity. These materials could be compatibly stored together and their toxic environmental hazards are well known.

Sodium cyanide (NaCn) is a toxic reagent and must, at all times, be stored and handled in isolation from other chemicals, particularly those which are acidic in nature, including the sulfate salts. This material would be shipped in 102 kg (225 lb) sealed drums on pallets. The reagent is essential to the metallurgical process as a depressant of iron minerals.

Methylisobutyl carbinol (MIBC) is an aliphatic liquid alcohol which has only a moderate solubility in water. It is moderately toxic to aquatic life and comparable in this respect to most intermediate molecular weight liquid alcohols. This chemical would be shipped in 181 kg (400 lb) steel drums and could be safely stored with the other chemicals.

Sodium isopropyl xanthate is an essential sulfide mineral collector in the flotation process, and is very toxic in the environment. It would be shipped in approximately 0.9 Mg (1 ton) sealed, palletized containers which preferably would be stored apart from acidic materials. A potential problem with xanthate is that it may deteriorate from prolonged contact with moisture and then would require disposal as it would be unusable as a reagent.

Sodium cetylsulfonate (EC-III) is a paste-like surface active agent used for barite flotation that has only a moderate solubility in water. It is essentially non-toxic and has been approved for use in food applications. This material would be shipped in 181 kg (400 lb) steel drums on pallets and would be compatible with all other reagents.

Sulfuric acid (H_2SO_4) is a hazard to aquatic life by virtue of pH reduction effects. Because of its liquid nature, spills would be difficult to contain and the chemical could have long lasting impacts on vegetation recovery unless lime were applied as a neutralizing agent. Sulfuric acid would be stored at the port in an isolated, berm-protected bulk tank and hauled to the mine in acid standard tank trailers of 24,227 ℓ (6,400 gal) capacity.

Lime would be used as a pH modifier in the mill flotation process and in the wastewater treatment plant. It is only toxic in concentrations which result in high alkalinity and would be relatively safe to manage in the hydrated form. It would be shipped and stored in heavy-wall plastic bags of about 1.8 Mg (2 tons) capacity. There would be no constraints on its storage with other reagents.

Polyacrylamide flocculant (Percol 730) is a slowly water soluble, high molecular weight, acrylamide-based polymer that would be used as a solids settling aid in the wastewater treatment plant. This material is relatively nontoxic. It would be shipped in 23 kg (50 lb) sacks on pallets and must be protected from temperature extremes in storage or its effectiveness might deteriorate.

The mill would produce lead, zinc and barite concentrates. Lead and zinc concentrates would be shipped to the port site in covered gondola-type trailers while barite would be moved in sealed containers on flat bed units.

The mill would operate on a continuous, round-the-clock basis for an estimated 350 days per year. Initial and final mill production rates are shown in Table II-1. Concentrates would be transported from the mill site to the main storage terminal at the port site in truck/trailer units. Approximately nine to 12 daily truck trips to the seaport would be required to handle the estimated daily production rate. Six weeks' production of concentrates could be stored at the mill to allow for transportation delays during periods of bad weather, when the roads were unsafe for travel, or if transportation activities were temporarily suspended to protect subsistence activities or animal migrations.

Wastewater Treatment Plant

Excess water from the mill process and site runoff would accumulate in the tailings pond. By federal law only water from precipitation in excess of evaporation can be discharged, and it must meet federal water quality criteria for metals and suspended solids. All discharged water would be drawn from the tailings pond and passed through a chemical treatment process to reduce metals and suspended solids concentrations. Normal discharge of treated water into the main stem of Red Dog Creek 19 m (62 ft) below its confluence with the South Fork (Fig. II-1) would occur during ice free months from May to October.

The proposed treatment plant would be based on a High Density Sludge (HDS) process that would use lime to neutralize acidity and precipitate soluble metals as hydroxides, followed by flocculant-induced clarification to remove solids. Treatment plant process reliability would depend on a substantial degree of internal sludge recycle to produce a final sludge with about 10 times the density that could be achieved without recycle. This feature is designed to enhance clarification and reduce the volume of waste sludge by an order of magnitude. Approximately 9 Mg (10 tons) of sludge solids as a 25 percent pulp density slurry would be produced each operating day.

Worker Housing

A campsite or hotel-style facility would be constructed a reasonable distance from the mill site complex. The actual location of the accommodations would be more specifically defined during the detailed design stage of the project in accordance with Mining Safety and Health Administration (MSHA) regulations that mandate specific criteria for worker safety and comfort.

Approximately 225 to 250 full-time employees would comprise the project site workforce at any given time. Workers would be scheduled on a rotation of approximately two weeks on and two weeks off so the total project workforce would be twice that figure. The projected mine/mill workforce breakdown would be as follows:

Miners/Mill Operators	50 percent
Mechanics/Electricians	15 percent
Support	15 percent
Supervisory/Management	20 percent

Water Supply

The mill would be a major consumer of water so a guaranteed year-round water source would be essential to the project. Wells would not be feasible since the permanently frozen ground prohibits free-flowing water aquifers.

An approximately 25 ha (63 ac) water storage reservoir located on Bons Creek at the south end of Red Dog Valley would serve as the water supply (Fig. II-5). A rock-filled dam would be constructed on bedrock foundation near the existing airstrip, and a pipeline would follow the existing road system to the mill site. The reservoir would also serve as a domestic water supply. It would have a capacity of 1,462 dam^3 (1,185 ac-ft) of water to meet an expected total daily consumption rate of 1,136 ℓ/min (300 gal/min) for all the mine area facilities.

Power Generation

For the concentration of minerals to take place, a large amount of power would be expended in grinding to achieve a fineness which allows adequate liberation of lead sulfide, zinc sulfide and barite particles from waste particles. On an average basis, electric power at a rate of 19.3 kWh/Mg (17.5 kWh/ton) of mill feed would be required for the grinding process. In order to meet this and other support facility demands, a dedicated power plant would be necessary. The Red Dog project would consume approximately 10.2 MW, and an 18 MW diesel-based power plant would be installed to allow for down time of some generators.

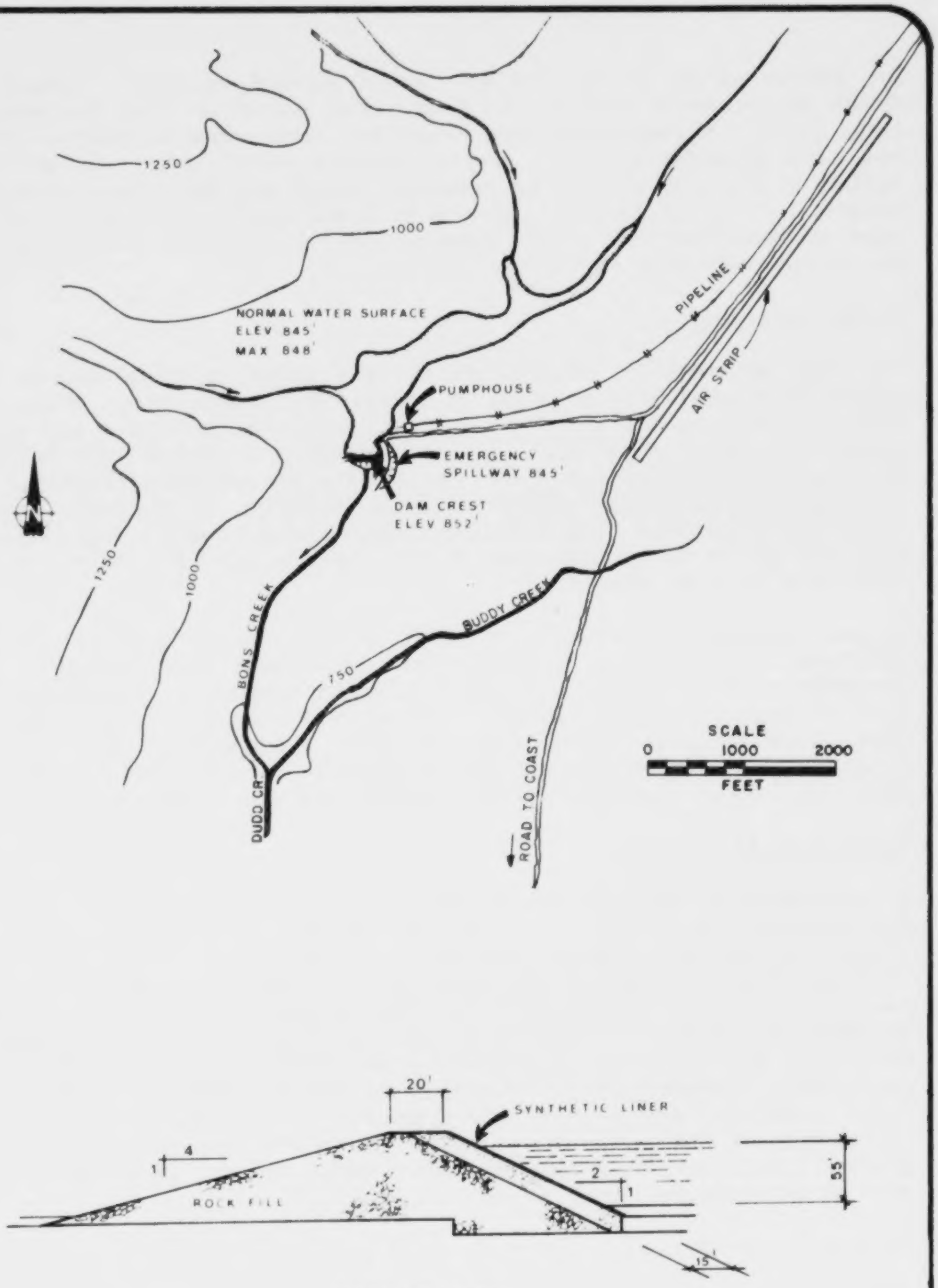
It was desirable to minimize both the loss of waste heat and air pollutant discharge by designing a system whereby waste heat would be used for concentrate drying, with the dryer exhaust treated in a scrubber or other type of pollutant control device. Diesel fuel storage and distribution facilities would be provided at the mill site. Fuel storage units (capacity of 4,800 bbls) would periodically be replenished from the main fuel depot at the coast by tanker trucks or by ore trucks specially fitted with tanker units.

Transportation Corridor

A transportation corridor would link the Red Dog Valley mine facilities with the Chukchi Sea coast. Two corridor options are included in the alternatives: a northern and a southern corridor (Fig. II-6). For the first 11.8 km (7.4 mi) the two corridors follow a common alignment. At a point near Dudd Creek, the northern corridor swings westward across the Wulik, Kivalina and Asikpak River drainages to a port site near Tugak Lagoon 24 km (15 mi) northwest of Kivalina. At Dudd Creek the southern corridor continues southwest along the flanks of the Mulgrave Hills to a port site near VABM 28, approximately 25.6 km (16 mi) southeast of Kivalina. The topography of both corridors would be gentle enough to handle railroad grades. Both corridors have therefore been laid out to accommodate a railroad at some future time.

Northern Corridor

The northern transportation corridor would be approximately 117.0 km (73.1 mi) long and would require the construction of six major (greater than 30.5 m [100 ft]) multiple-span bridges, six minor bridges and approximately 300 culverts. The route would traverse the main stems of Ikalukrok Creek, and the Kivalina, Wulik and Asikpak Rivers (Fig. II-6). It would cross approximately 12 streams which contain fish, including major char spawning


1250
1000
NORMAL WATER SURFACE
ELEV 845'
MAX 848'
PUMPHOUSE
EMERGENCY
SPILLWAY 845'
DAM CREST
ELEV 852'
PIPELINE
AIR STRIP
1250
1000
BONS CREEK
BUDDY CREEK
750
DUDD CR
ROAD TO COAST
SCALE
0
1000
2000
FEET
N
20'
SYNTHETIC LINER
1
4
ROCK FILL
2
1
55'
15'

DAM SECTION

FIGURE II -5 WATER STORAGE RESERVOIR

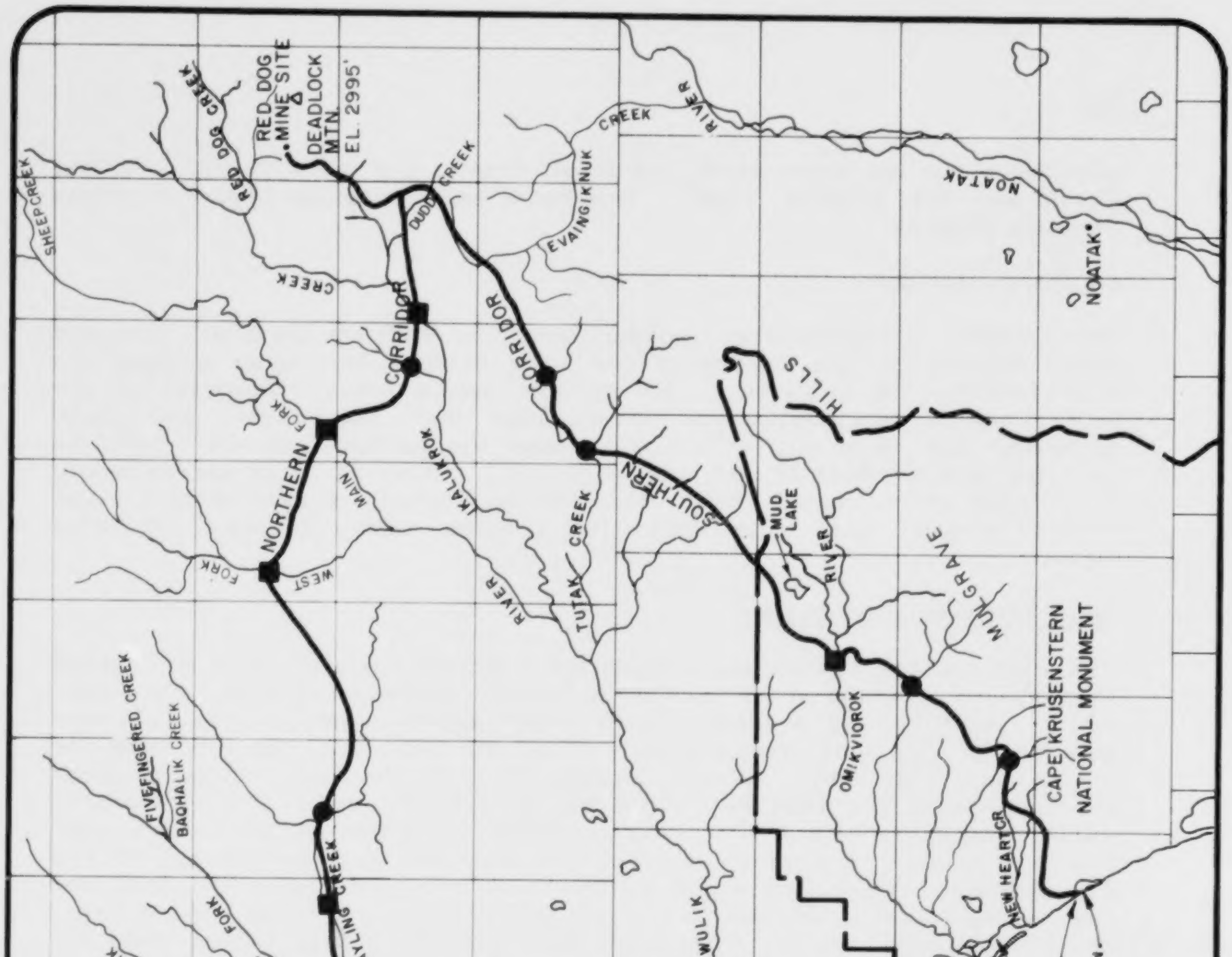

RED DOG MINE SITE
DEADLOCK MTN EL. 2995'
RED DOG CREEK
SHEEP CREEK
CREEK
DUDD CREEK
EVAINGIKNUK CREEK
NOATAK RIVER
NOATAK
HILLS
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
MAIN FORK
WEST FORK
IKALUKROK
RIVER
TUTAK CREEK
MUD LAKE
RIVER
MULGRAVE
OMIKVIOROK
CAPE KRUSENSTERN NATIONAL MONUMENT
NEW HEART CR
FIVEFINGERED CREEK
BAQHALIK CREEK
MAIN FORK
WEST FORK
GRAYLING CREEK
RIVER
WULIK
KIVALINA
ASIKPAK RIVER
RIVER
SINGOALIK
IPIAVIK LAGOON
VABM 28
PORT SITE
PORT LAGOON
IMIKRUK LAGOON
KIVALINA
SEA
CHUKCHI
KIVALINA LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
6 miles
10 kilometers
N
LEGEND
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
MAJOR BRIDGE CROSSING
MINOR BRIDGE CROSSING

FIGURE II-6
RED DOG PROJECT AREA

and overwintering areas along Ikalukrok Creek, the Wulik River, Grayling Creek and the Kivalina River. The route would provide access to these fisheries streams.

Southern Corridor

The southern transportation corridor would be 89.9 km (56.2 mi) long and would require the construction of one major bridge, four minor bridges and approximately 182 culverts. The corridor would cross tributaries of the Wulik, Noatak and Omikviorok Rivers near their headwaters, and would generally stay at a higher elevation than the northern corridor until its terminus at the VABM 28 port site (Fig. II-6). It would cross approximately 11 streams which contain fish. None of the streams is considered a major fishery stream; the route would not provide access to major fisheries streams.

Road Transportation System

The road haulage system would comprise a gravel surfaced road and double truck/trailer haulage units similar to normal highway vehicles, but oversized. A truck and a trailer would weigh approximately 103 Mg (114 ton) and 90 Mg (108 ton), respectively, or 201 Mg (222 tons) for one combined truck and trailer unit. Nine to 12 daily truck/trailer round trips to carry concentrates to the port site would be required for the first five years at initial production rates. Following proposed expansion of production after five years, daily concentrate transport trips would average between 16 and 20. Additional daily tanker and supply truck trips and one or two trips per day by light utility vehicles would also occur. Inbound freight would likely be containerized, though some specialized trailers such as tanker units (to haul fuel oil to the mill site) would be required. Continuous maintenance of the roadway would be necessary, thus requiring a full complement of road maintenance and repair equipment.

Road Construction

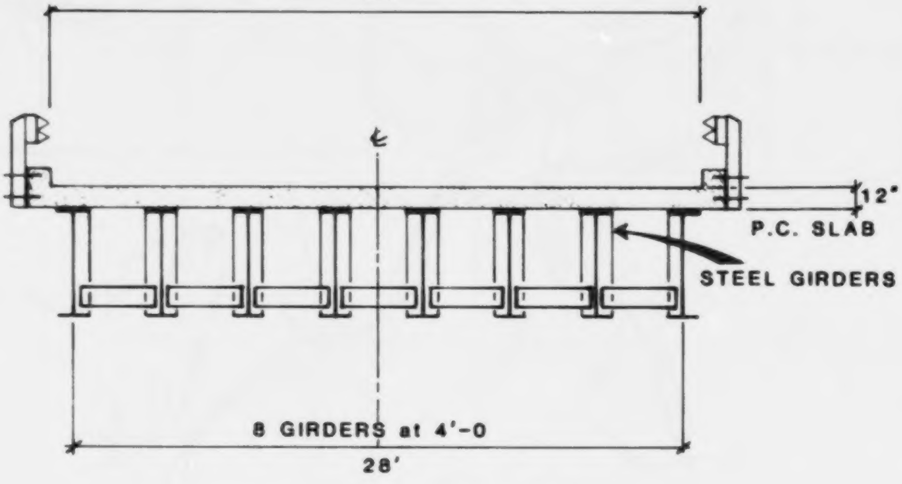
Gravel or competent soils are the desirable materials for construction of the road either as a base or as topping material. The roadbed or subbase would be composed of granular fill 2.0 m (6.5 ft) thick to prevent degradation of permafrost. The top surface of the road would be 9 m (30 ft) in width as shown on Figure II-7. Turnouts and passing places would be provided along the route. Curvature and grade would generally be limited to 10 degrees and three percent, respectively, to permit eventual construction of a railroad. Bridge structures and culverts would be designed to accommodate year-round concentrate haulage by combined truck/trailer units.

Borrow Sites*

Because few gravel sources have been identified along the corridors, the majority of fill needed for road construction would come from rock quarry borrow sites. An overview of potential borrow sites along the southern corridor is shown on Figure II-8. Locations of these borrow sites are shown

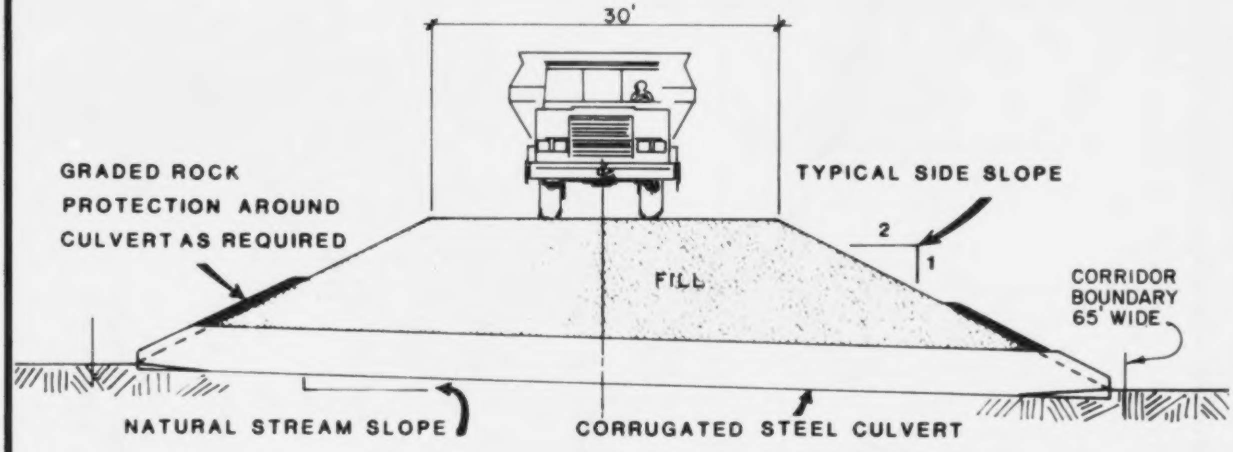
---

* Defined in Glossary.


30'
℄
12"
P.C. SLAB
STEEL GIRDERS
8 GIRDERS at 4'-0
28'

TYPICAL BRIDGE CROSSING

0
2'


30'
GRADED ROCK
PROTECTION AROUND
CULVERT AS REQUIRED
TYPICAL SIDE SLOPE
2
1
FILL
CORRIDOR
BOUNDARY
65' WIDE
NATURAL STREAM SLOPE
CORRUGATED STEEL CULVERT

TYPICAL CULVERT CROSSING

0
15'

FIGURE II-7 TYPICAL BRIDGE
& CULVERT CROSSINGS

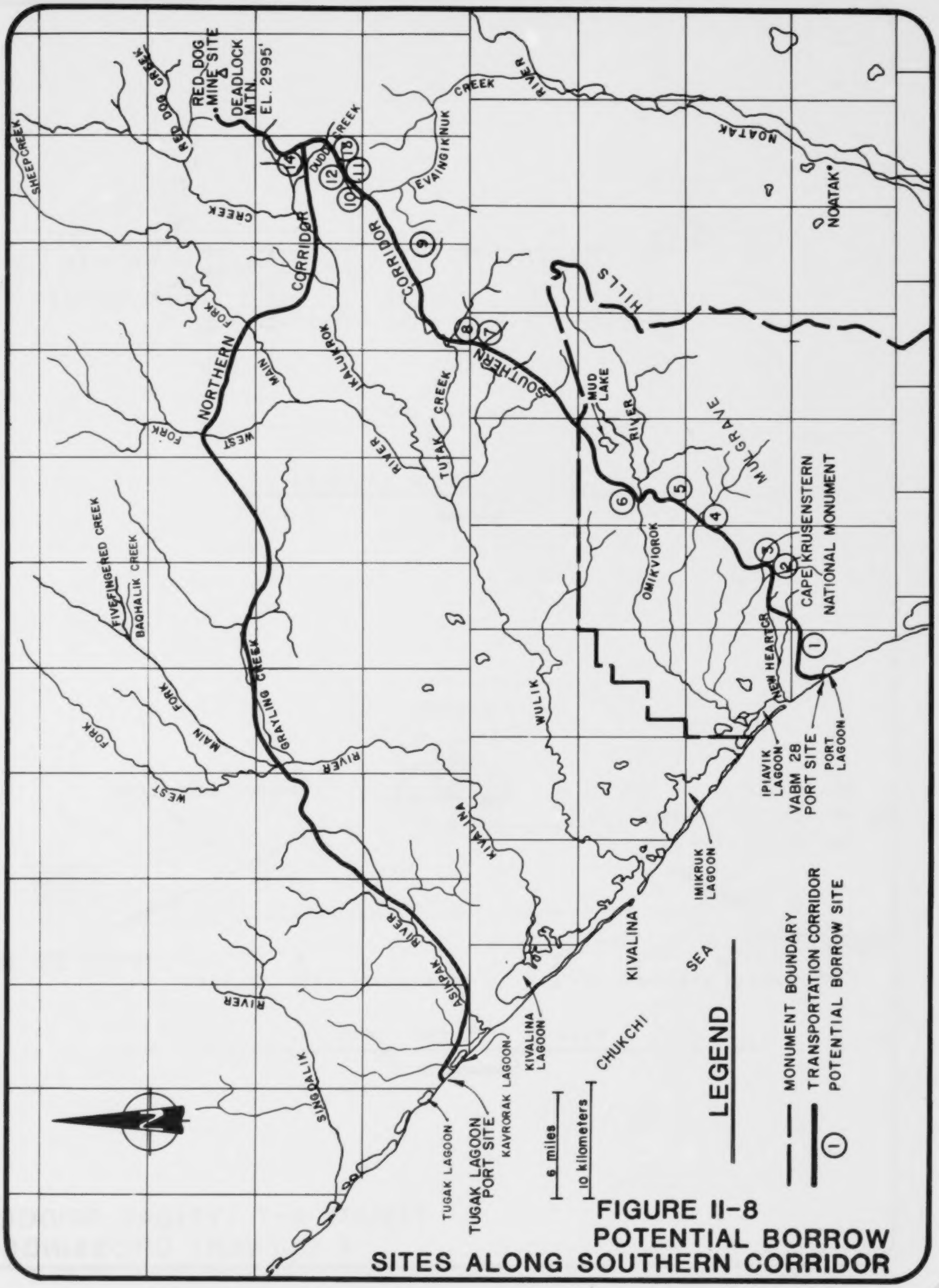

RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
RED DOG CREEK
SHEEPCREEK
CREEK
DUDD CREEK
EVAINGIKNUK CREEK
NOATAK RIVER
NOATAK
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
MAIN FORK
WEST FORK
IKALUKROK
RIVER
TUTAK CREEK
HILLS
MUD LAKE
RIVER
MULGRAVE
OMIKVIOROK
CAPE KRUSENSTERN NATIONAL MONUMENT
NEW HEART CR.
FIVEFINGERED CREEK
BAQHALIK CREEK
GRAYLING CREEK
MAIN FORK
WEST FORK
RIVER
WULIK
KIVALINA
ASIKPAK RIVER
SINGOALIK RIVER
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
IMIKRUK LAGOON
KIVALINA
CHUKCHI SEA
KIVALINA LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
N
6 miles
10 kilometers
LEGEND
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
① POTENTIAL BORROW SITE
①
②
③
④
⑤
⑥
⑦
⑧
⑨
⑩
⑪
⑫
⑬
⑭

FIGURE II-8
POTENTIAL BORROW
SITES ALONG SOUTHERN CORRIDOR

in more detail on Figures II-9 through II-13. In addition, specific information about each potential borrow site, including surface area and volume of material to be extracted, is shown in Table II-3. This is preliminary information that could change as better field data are collected for the detailed design and permitting phases of the project. Preliminary borrow site information is not available for the northern corridor.

In the event that a right-of-way was granted across Cape Krusenstern National Monument, but borrow extraction was not permitted within the boundaries of the Monument, all borrow material would be extracted from Sites 7 to 14 (Fig. II-8). Anticipated changes in borrow site specifications (area, volume, etc.) are shown in Table II-4. Sites 7 and 8 would be expanded in surface area and excavation depth to compensate for the change in the total number of sites, and to provide the necessary volume of borrow material. In addition, the main concentrate storage building would be located at the port site rather than 4.0 km (2.5 mi) inland at Borrow Site 1.

Port Site

Though operations at the mine would continue year-round, activity at the deep-draft port site would be limited to the receipt of supplies and fuel during the summer sealift, and the shipment of concentrates from late June until early October. Climatic constraints on shipping activities thus require that adequate storage facilities for concentrates, fuel and other supplies exist at the port site. Using an all-weather road, it is estimated that eight and a half months of concentrate storage capacity would be required at the port site.

Schematics of the approximately 20 ha (50 ac) proposed port site facilities are shown on Figures II-14 and II-15. Depending upon the type of transfer facility (described below), fuel would be stored either onboard an "offshore island" or in tanks on land at the port site. In either case, a year's supply would be kept there to serve as the main fuel depot for the project. Fuel would be periodically hauled to the mine site as required. A short causeway/dock structure would be required to receive incoming freight and supplies, and for transfer of the concentrates for shipment.

Only emergency and temporary ship loading crews would be housed at the port site. A small accommodation complex would be provided to support activities during the summer shipping season. Domestic sewage would be collected and treated using a package treatment facility before discharge into the sea. An NPDES permit (separate from the major permit) would be required for discharge at the port facility. A small diesel-based 1.5 MW power plant would be required to operate conveyor equipment and life support facilities.

In addition to the facilities located immediately at the coast, the main concentrate storage building would be located approximately 4.0 km (2.5 mi) inland, adjacent to the transportation corridor at about the 76 m (250 ft) elevation (Fig. II-16). This structure would be constructed at excavated Borrow Site 1 to minimize habitat destruction, and to take advantage of foundation materials and protection from the wind.

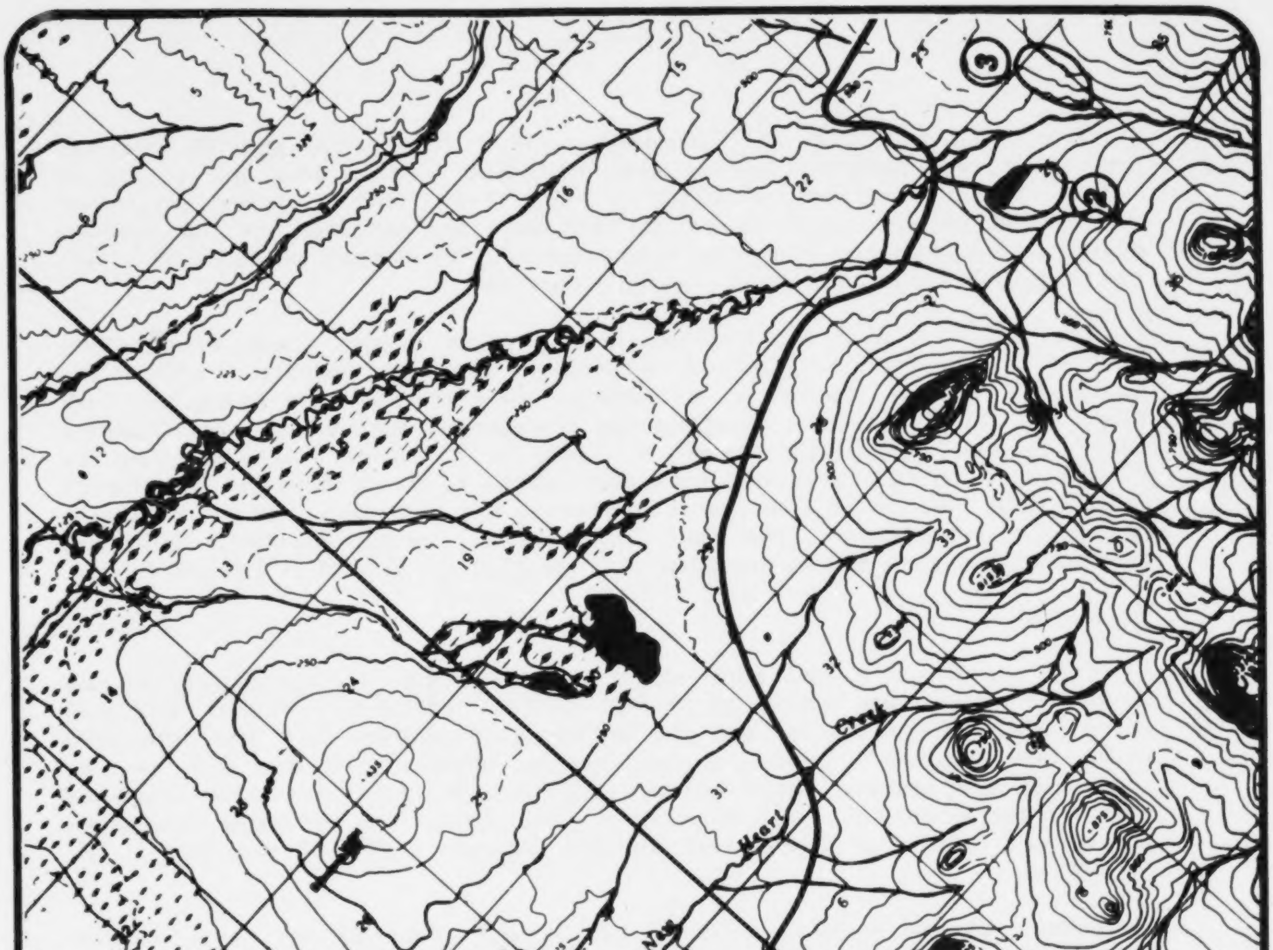
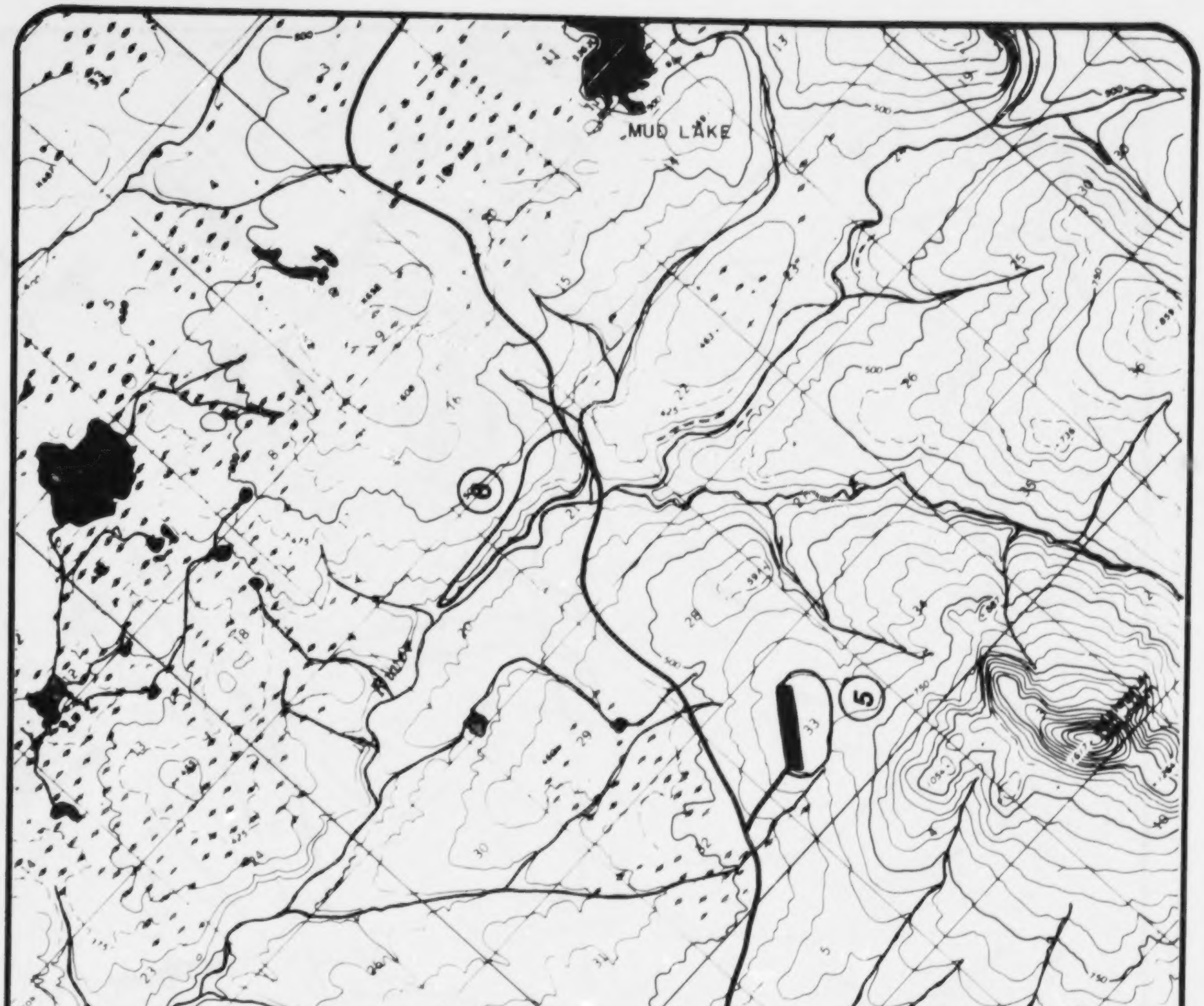

3
2
1
IPIAVIK LAGOON
PORT LAGOON
VABM 28 PORT SITE
CHUCKCHI SEA
1 mile
GRAVEL PIT
EXPLORATION AREA

FIGURE II-9
LOCATION OF POTENTIAL
BORROW SITES 1, 2 & 3



MUD LAKE
6
5
4
1 mile
GRAVEL PIT
EXPLORATION AREA

FIGURE II-10
LOCATION OF POTENTIAL
BORROW SITES 4, 5 & 6

Reproduced from
best available copy.

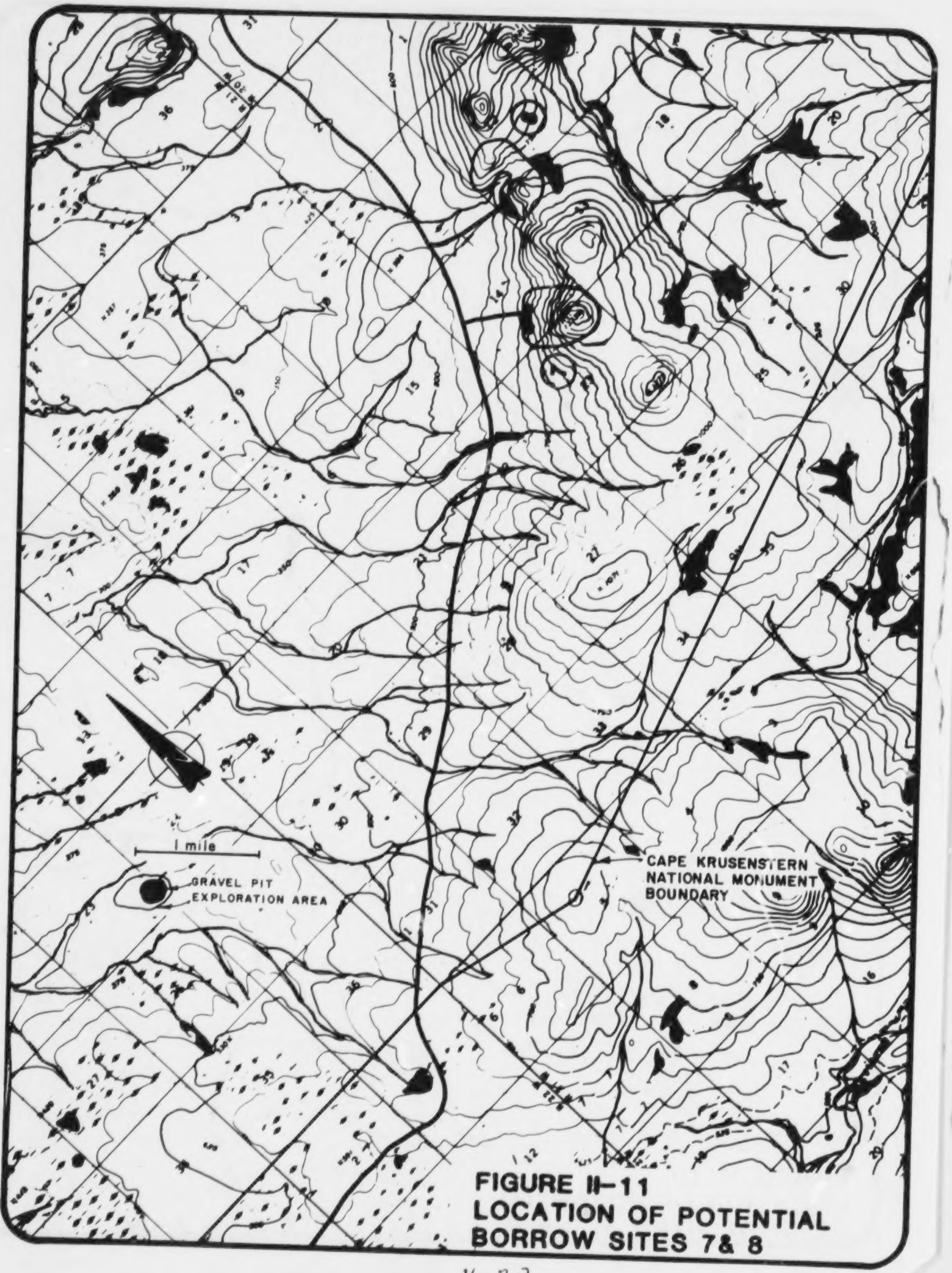

1 mile
GRAVEL PIT
EXPLORATION AREA
CAPE KRUSENSTERN
NATIONAL MONUMENT
BOUNDARY

FIGURE II-11
LOCATION OF POTENTIAL
BORROW SITES 7& 8

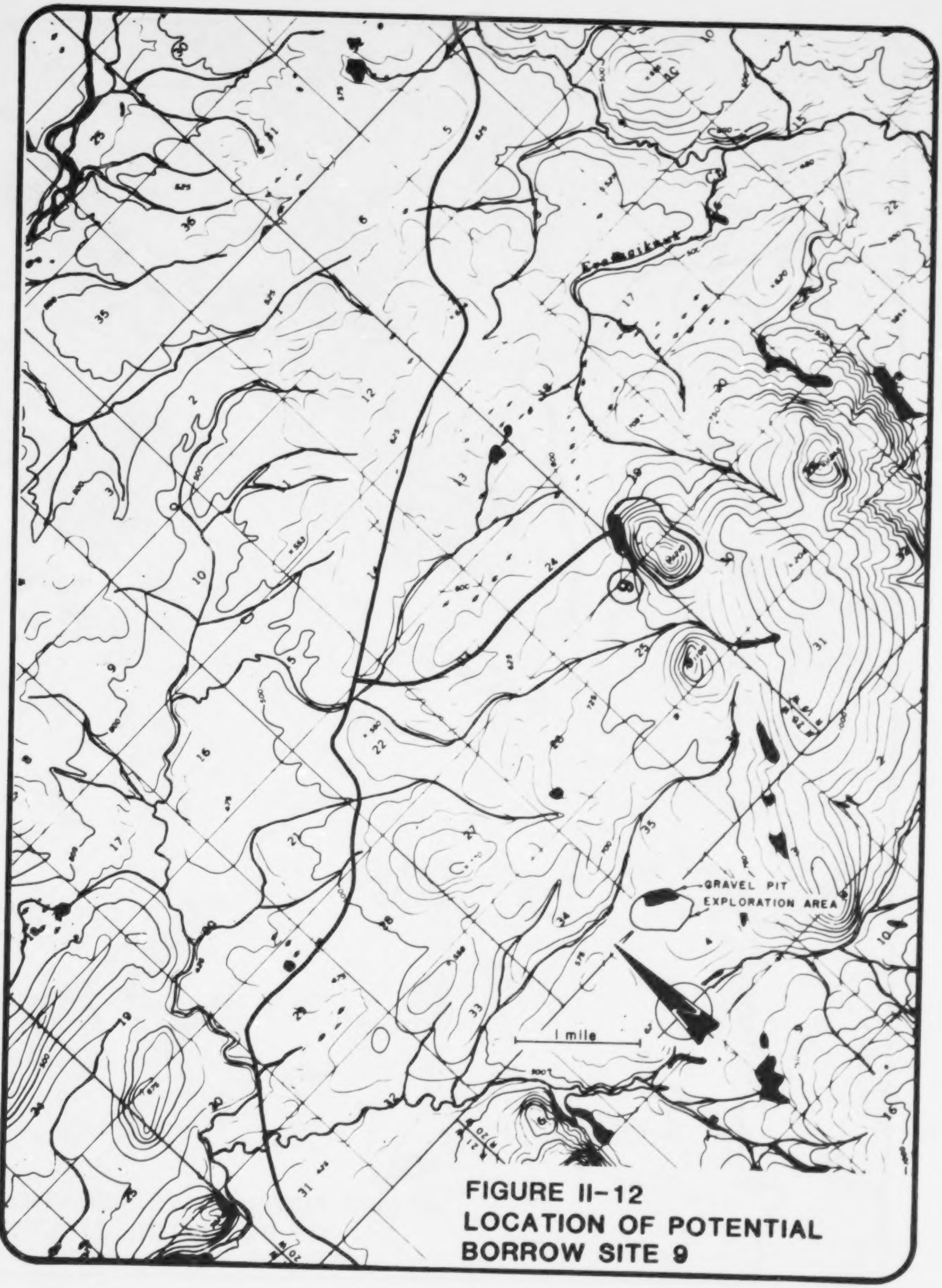

GRAVEL PIT
EXPLORATION AREA
1 mile

FIGURE II-12
LOCATION OF POTENTIAL
BORROW SITE 9

Reproduced from best available copy.

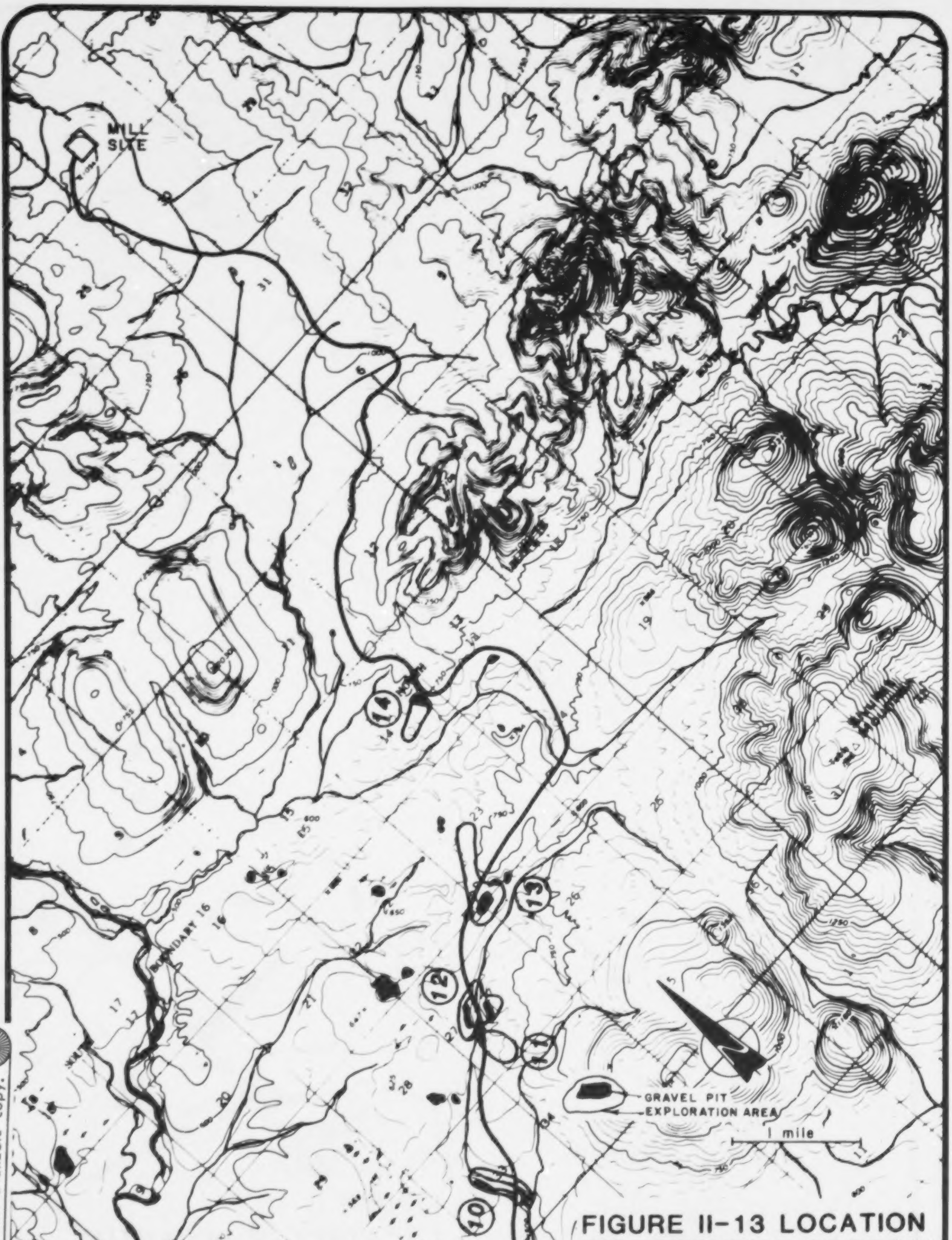

MILL SITE
14
13
12
11
10
BOUNDARY 16
GRAVEL PIT
EXPLORATION AREA
1 mile

FIGURE II-13 LOCATION OF POTENTIAL BORROW SITES 10,11, 12, 13 & 14

Table II-3

PRELIMINARY BORROW SITE SPECIFICATIONS, SOUTHERN CORRIDOR

Borrow Site Number	Exploration Area		Disturbed Pit Area		Approximate Volume Needed		Average Excavation Depth		Access Road Length		Within 91 m (300 ft) of Stream
	ha	ac	ha	ac	m^3	yd^3	m	ft	km	mi	
1*	85.5	211.2	19.4	48.0	305,853	400,043	2.1	7.0	0.19	0.12	No
2	49.2	121.6	9.5	23.4	289,144	378,188	3.0	10.0	0.39	0.24	No
3	57.0	140.8	--	--	--	--	--	--	--	--	No
4	98.4	243.2	5.2	12.8	190,189	248,760	4.9	16.0	1.29	0.80	No
5	77.7	192.0	13.9	34.4	590,100	771,826	4.3	14.0	1.08	0.67	No
6	163.2	403.2	--	--	--	--	--	--	--	--	Yes
7	67.3	166.4	2.4	6.0	149,447	195,471	6.1	20.0	0.48	0.30	No
8	59.6	147.2	5.0	12.4	307,096	401,669	6.1	20.0	1.06	0.66	Yes
9	88.1	217.6	5.6	13.8	422,903	553,140	7.6	25.0	3.96	2.46	No
10	20.7	51.2	6.3	15.5	246,600	322,543	4.0	13.0	0.24	0.15	Yes
11	20.7	51.2	3.0	7.3	54,008	70,640	1.8	6.0	0.16	0.10	No
12	16.8	41.6	3.0	7.3	54,008	70,640	1.8	6.0	0.16	0.10	No
13	36.3	89.6	6.5	16.1	174,850	228,697	2.7	9.0	0.16	0.10	No
14	15.5	38.4	4.6	11.5	171,703	224,580	3.6	12.0	0.08	0.05	No

* Would also serve as the coastal concentrate storage facility site after borrow excavation.

Table II-4

PRELIMINARY BORROW SITE SPECIFICATIONS IF ALL BORROW MATERIAL WAS TAKEN FROM OUTSIDE CAPE KRUSENSTERN NATIONAL MONUMENT

Borrow Site Number	Exploration Area		Disturbed Pit Area		Approximate Volume Needed		Average Excavation Depth		Access Road Length		Within 91 m (300 ft) of Stream
	ha	ac	ha	ac	m^3	yd^3	m	ft	km	mi	
7	80.8	199.6	9.9	24.5	760,569	994,793	7.6	25.0	0.48	0.30	No
8	71.5	176.6	10.2	25.3	974,211	1,274,228	9.1	30.0	1.06	0.66	Yes
9	88.1	217.6	5.6	13.8	422,903	553,140	7.6	25.0	3.96	2.46	No
10	20.7	51.2	6.3	15.5	246,600	322,543	4.0	13.0	0.24	0.15	Yes
11	20.7	51.2	3.0	7.3	54,008	70,640	1.8	6.0	0.16	0.10	No
12	16.8	41.6	3.0	7.3	54,008	70,640	1.8	6.0	0.16	0.10	No
13	36.3	89.6	6.5	16.1	174,850	228,697	2.7	9.0	0.16	0.10	No
14	15.5	38.4	4.6	11.5	171,703	224,580	3.6	12.0	0.08	0.05	No

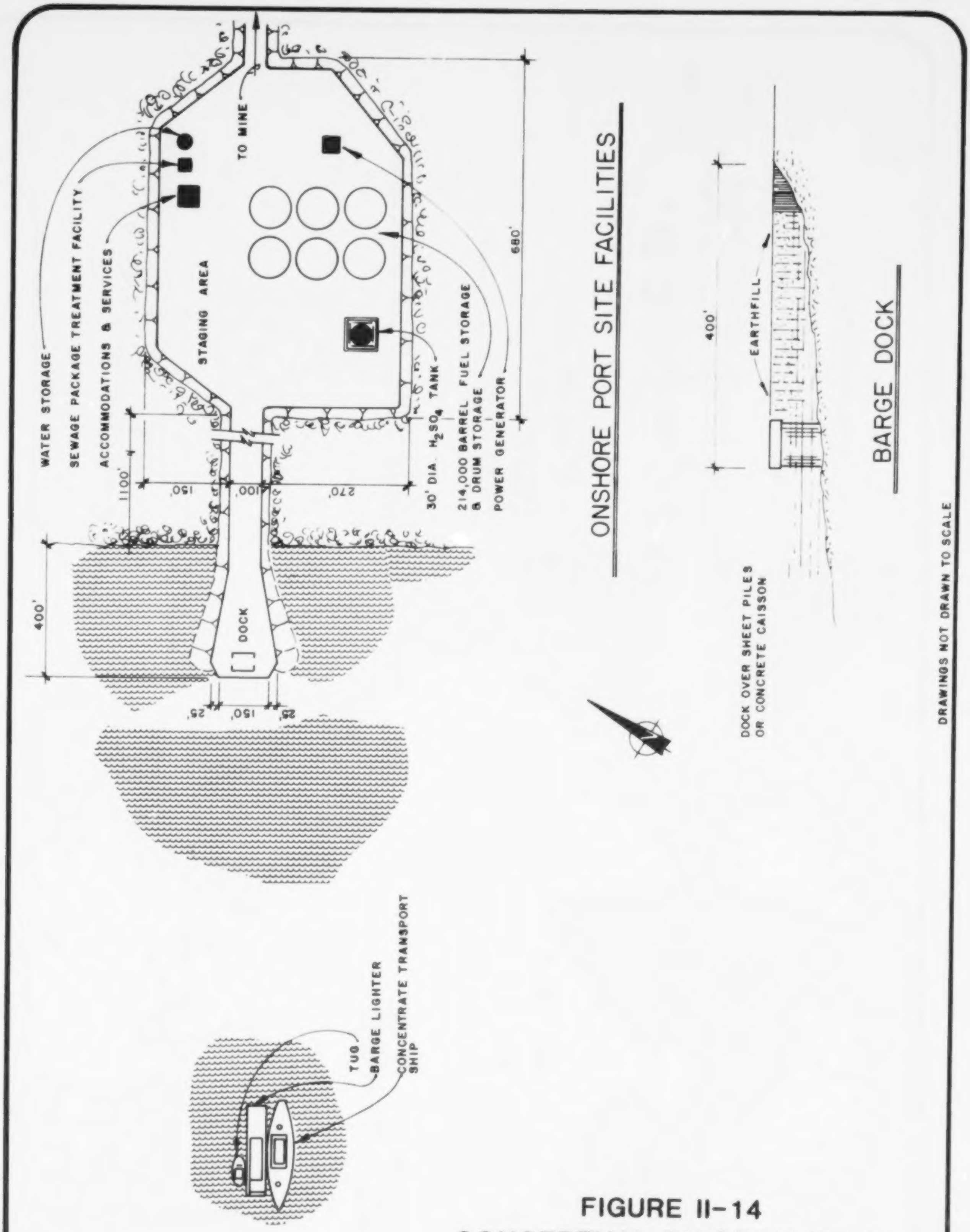

WATER STORAGE
SEWAGE PACKAGE TREATMENT FACILITY
ACCOMMODATIONS & SERVICES
STAGING AREA
TO MINE
680'
1100'
150'
100'
270'
30' DIA. H_2SO_4 TANK
214,000 BARREL FUEL STORAGE
& DRUM STORAGE
POWER GENERATOR
400'
DOCK
25'
150'
25'
ONSHORE PORT SITE FACILITIES
400'
EARTHFILL
BARGE DOCK
DOCK OVER SHEET PILES
OR CONCRETE CAISSON
DRAWINGS NOT DRAWN TO SCALE
TUG
BARGE LIGHTER
CONCENTRATE TRANSPORT
SHIP

FIGURE II-14

CONCEPTUAL DIAGRAM OF A SHORT CAUSEWAY/LIGHTERING TRANSFER FACILITY

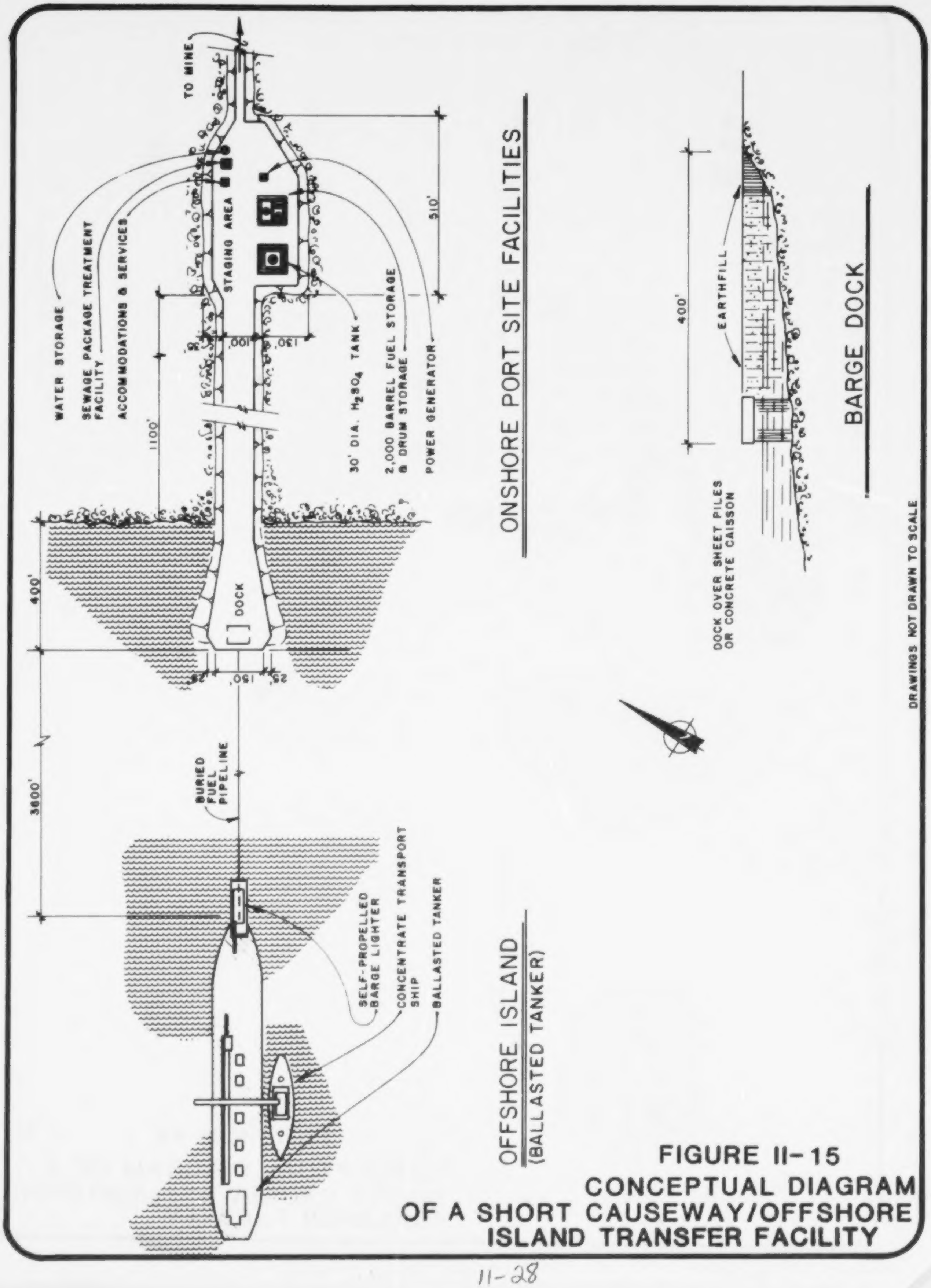
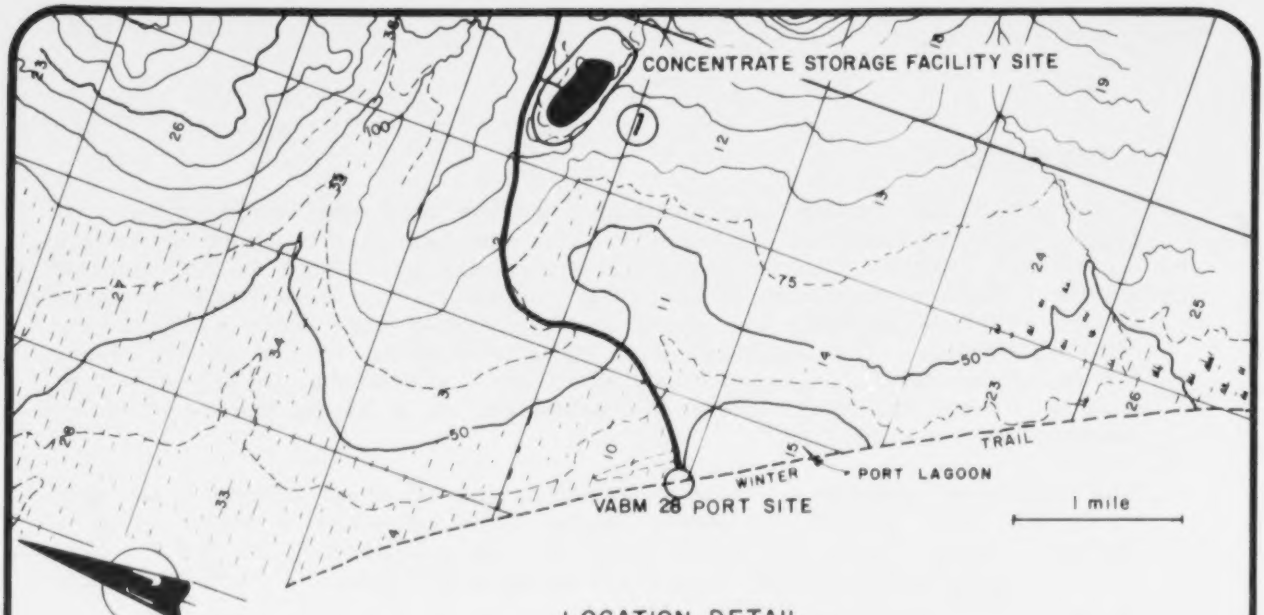
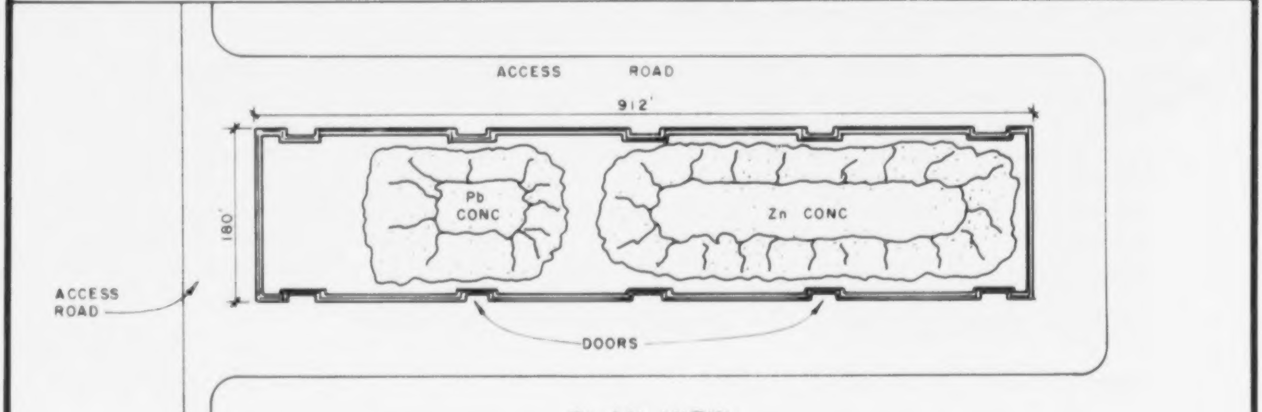

TO MINE
WATER STORAGE
SEWAGE PACKAGE TREATMENT FACILITY
ACCOMMODATIONS & SERVICES
STAGING AREA
510'
1100'
100'
130'
30' DIA. H_2SO_4 TANK
2,000 BARREL FUEL STORAGE & DRUM STORAGE
POWER GENERATOR
400'
DOCK
25'
150'
150'
25'
3600'
BURIED FUEL PIPELINE
SELF-PROPELLED BARGE LIGHTER
CONCENTRATE TRANSPORT SHIP
BALLASTED TANKER
ONSHORE PORT SITE FACILITIES
OFFSHORE ISLAND
(BALLASTED TANKER)
400'
EARTHFILL
DOCK OVER SHEET PILES OR CONCRETE CAISSON
BARGE DOCK
DRAWINGS NOT DRAWN TO SCALE

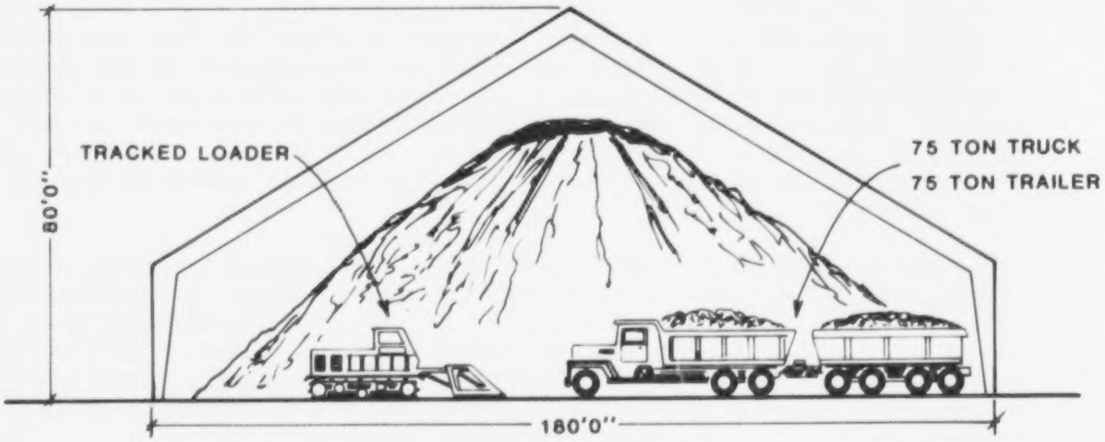
FIGURE II-15
CONCEPTUAL DIAGRAM
OF A SHORT CAUSEWAY/OFFSHORE
ISLAND TRANSFER FACILITY


CONCENTRATE STORAGE FACILITY SITE
1
VABM 28 PORT SITE
WINTER
TRAIL
PORT LAGOON
1 mile
75
50
100

LOCATION DETAIL


ACCESS ROAD
912'
180'
Pb CONC
Zn CONC
ACCESS ROAD
DOORS

PLAN VIEW


TRACKED LOADER
75 TON TRUCK
75 TON TRAILER
80'0"
180'0"

BUILDING CROSS SECTION

FIGURE II-16
COASTAL CONCENTRATE STORAGE FACILITY

Transfer Facility

Two methods to transfer concentrates from the port site storage facility to ocean going vessels are included in the alternatives: a short causeway/lightering* transfer system and a short causeway/offshore island transfer system. Both systems would use a 122 m (400 ft) causeway/dock structure as an interface between the shore and the concentrate loading vessels or offshore island. The causeway/dock structure would extend to the 4.6 m (15 ft) water depth. Concentrates would be transferred by conveyor belt from a storage building, along the causeway, to a barge loader structure mounted on the dock face.

The causeway structure would be constructed of sheet pilings with solid earth fill (Fig. II-14). It would be suitably capped and faced to allow lighter* barges to tie up at its seaward face. Depending on the transfer facility option selected, lighter barges ranging from 907 to 4,535 Mg (1,000 to 5,000 tons) would be used.

Short Causeway/Lightering System

This transfer method would use two 4,535 Mg (5,000 ton) lighters and two support tugs to transfer concentrates from the dock directly to the side of a moored ocean going bulk-handling ship (Fig. II-14). The ocean going vessel would load concentrates with clam shell cranes, though rough sea conditions might make this transfer method unreliable. Winter shelter for the two large-capacity lighters and their tugs would be provided in a coastal lagoon located adjacent to the port facilities. The barrier beach between the lagoon and the sea would be breached by bulldozing each fall and spring for winter harboring. Lighters would also be sheltered in the lagoon during severe storms. No dredging would take place within the lagoon.

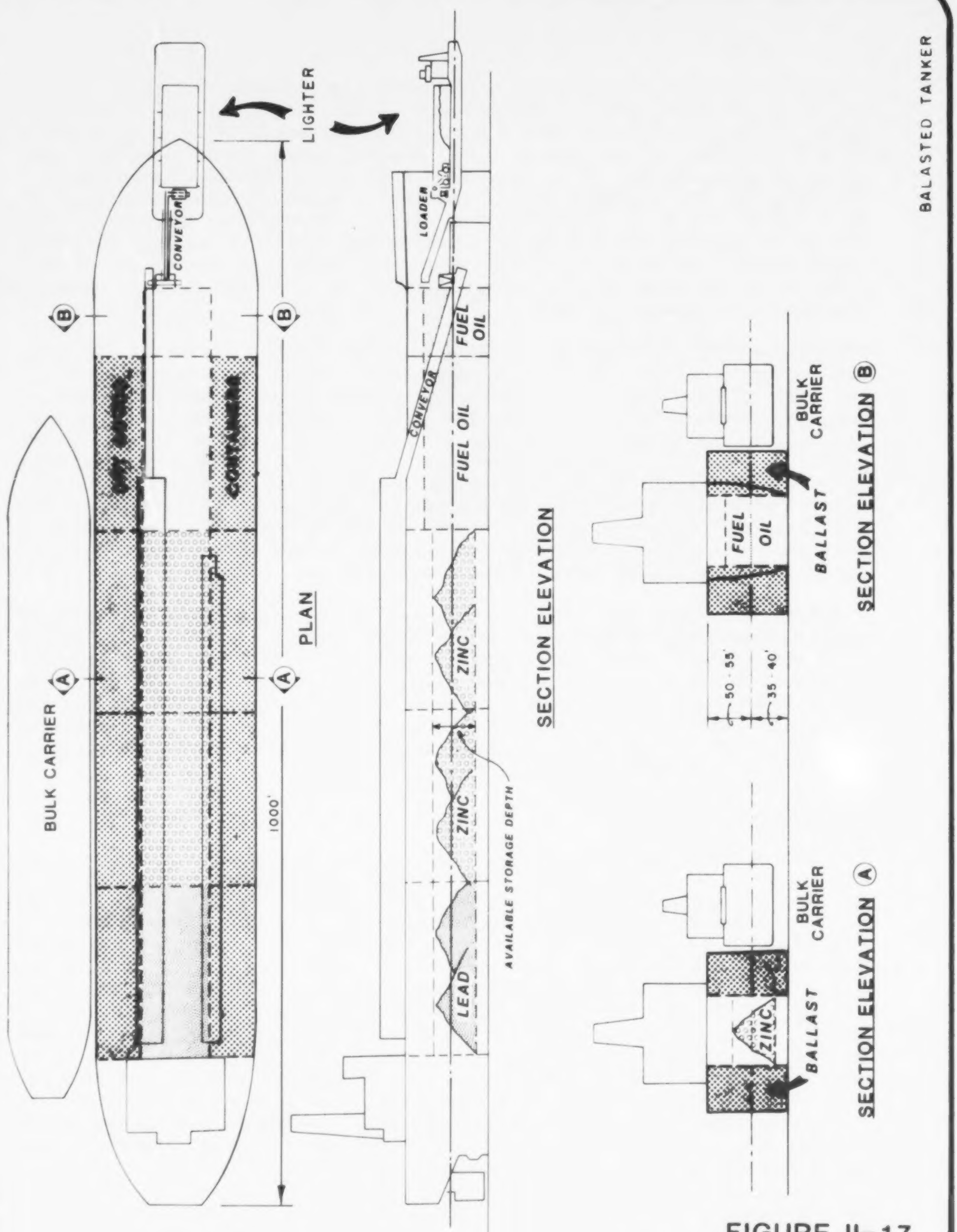
Short Causeway/Offshore Island

This transfer method would use an approximately 226,750 Mg (250,000 ton) Very Large Crude Carrier (VLCC) surplus oil tanker as an "offshore island" dock for the smaller, ocean going bulk carriers (Fig. II-15). Prior to being ballasted perpendicular to shore at a prepared bottom location, the outer hull of this 305 m (1,000 ft) tanker would be ice strengthened by the addition of approximately 544 Mg (600 tons) of new, corrosion-protected steel plate. In addition, about 181 Mg (200 tons) of steel would be provided for additional bulkheads in the ship's internal tanks. Approximately 72,628 m^3 (95,000 yd^3) of gravel ballast would be used to stabilize the vessel on the sea floor (Fig. II-17).

Sea floor preparation for tanker placement would require dredging of material in the specific placement area so that the exterior edges of the tanker would rest on berms, while the central axis of the ship would settle in a slight depression. This would place the hull bottom in tension. Gaps under the hull would then be filled with additional dredged material, thus creating a stable "bed" in which the bottom of the tanker would be firmly seated.

---

* Defined in Glossary.



LIGHTER
CONVEYOR
LOADER
B
A
PLAN
BULK CARRIER
1000'
DRY BULK
CONTAINERS
FUEL OIL
FUEL OIL
ZINC
ZINC
LEAD
CONVEYOR
AVAILABLE STORAGE DEPTH
SECTION ELEVATION
50-55'
35-40'
BALLAST
BULK CARRIER
SECTION ELEVATION Ⓐ
SECTION ELEVATION Ⓑ
BALASTED TANKER

FIGURE II-17
BALLASTED TANKER
TRANSFER & STORAGE FACILITY

The landward end of the tanker would be in approximately 9.1 to 10.7 m (30 to 35 ft) of water and the seaward end in 10.7 to 12.2 m (35 to 40 ft) of water. The tanker would have a molded sidewall height of 24 to 27 m (80 to 90 ft) depending on the type of VLCC selected, which would provide a freeboard of approximately 12 to 18 m (40 to 60 ft). Depending upon the port site selected, the landward end of the tanker would be approximately 1,067 to 1,219 m (3,500 to 4,000 ft) from shore. The tanker would be large enough to accommodate storage of concentrates, fuel and supplies in center compartments protected from the sea by two layers of steel (Fig. II-17). Onboard concentrate storage capacity would be sufficient to load three to five ocean going bulk carriers.

The bow of the ship would be modified to accommodate a 907 Mg (1,000 ton), self-unloading lighter which would discharge directly by conveyor belt into the ship (Fig. II-17). Only one self-propelled lighter would be needed to transport concentrates because of the storage capacity onboard the tanker. Shelter for the single, smaller lighter could be provided in the lee of the tanker if necessary during bad weather. Winter shelter and protection from severe storms would be provided in a coastal lagoon adjacent to the port site. The lagoon would be breached each fall and spring for winter harboring, but no dredging would take place within the lagoon. If ice conditions were suitable, winter transfer of concentrates to the tanker island might be accomplished by trucks driven directly over the ice.

Transfer of concentrates from the ballasted tanker to bulk carriers would be accomplished using moveable conveyors between ships which would be loaded from storage by a clam shell bucket. Similar to the shore-based system, conveyors would be covered, and the end of the loader would be fitted with a telescoping spout or "elephant's trunk", to direct the concentrate into the receiving ship's hold below deck level. Conveyor return belts would be brushed in an enclosure to prevent losses to the sea. Sealed barite containers would be loaded by crane.

Fuel Storage

Location of the major fuel storage depot for the project would depend upon the transfer facility selected. For the short causeway/lightering option a full year's supply of fuel for the project, as well as fuel to meet the annual needs of the region's villages, would be stored in tanks on land at the port site (Fig. II-14). The fuel would be lightered to the dock from ships moored offshore and then transferred by pipe to onshore storage tanks. These tanks would be constructed either on well drained gravel pads or on pilings to preclude heaving or jacking problems that could result in tank failure. Spillage containment dikes and synthetic liners would be installed around the tank structures. Storage capacity of the onshore fuel tanks would total approximately 214,000 bbls with about 56 percent of that (120,000 bbls) being for the project. Fuel would be hauled to the mine area facilities by tanker truck as needed during the year. It would be distributed to the villages from the port site using the same smaller barges as presently used by local barge services to navigate the rivers.

For the offshore island option, the same amount of fuel would be transferred directly into the ballasted tanker from fuel transport ships and stored in tanks aboard the ship (Fig. II-17). It would be moved to shore year-round through a 10-cm (4-in) diameter steel pipe (schedule 40) surrounded by a 15-cm (6-in) diameter steel guard pipe. The pipeline would be buried in the sea bed below ice gouge depth. Flow detectors would be used to monitor fuel transfer operations to give immediate indication of pipeline leakage or unusual transfer conditions. As an extra precaution, a fuel leak detection system would be installed to detect leakage from the 10-cm (4-in) transfer pipe into the space between the two pipes. Fuel would be stored at the port site to a capacity of approximately 2,000 bbls (Fig. II-15). It would then be transported to the mine area facilities by tanker truck as needed. Regional village fuel would be distributed by barges directly from the tankers.

DEVELOPMENT SCHEDULE

As is the case with any endeavor in the Arctic, the critical factor affecting the development schedule is the limited shipping season (generally July through September). Within these confines and assuming a project start-up date of January 1985, key periods in the development schedule are discussed below.

Construction equipment for road building activities would be landed at the port site during the summer of 1985. This equipment would be idled until freeze-up occurred prior to moving inland to the first borrow site. From January to July of 1986, a road would be built inland from the first borrow site, as well as back to the port site.

The first major construction sealift of equipment and materials would be made in the 1986 shipping season. The equipment for constructing the main road, as well as the mining equipment, would be brought in at that time. A small 20-person "fly-in" construction camp would be set up at the Red Dog mine site. A self-contained barge-mounted camp would be located in a lagoon at the port site to support construction activity during the same sealift (Fig. II-18). The barrier beach between the lagoon and the sea would be breached by a bulldozer during the first season to position the barge in the lagoon. The 100-person barge camp would remain in the lagoon for the two to three seasons required for construction of the port site facilities. The lagoon would be rebreached to remove the barge after the port facilities were established. The barge would then be converted to the self-propelled concentrate transport lighter.

In January of 1987 the main road would be completed from the port site to Red Dog Valley. Construction equipment to prepare the mill site, as well as mining equipment to begin development work, would then be moved to the site. Additional camp facilities (for 50 people) would also be moved over the road to the Red Dog site at that time. Mine development would continue through 1987 to the time of production mining start-up in early 1988. Suitable mine waste would be used to construct the tailings pond dam during this period. To the extent that schedule constraints would allow, initial mine work would be carried out by permanent crews so that fully trained personnel would be available by the commencement of full operation.

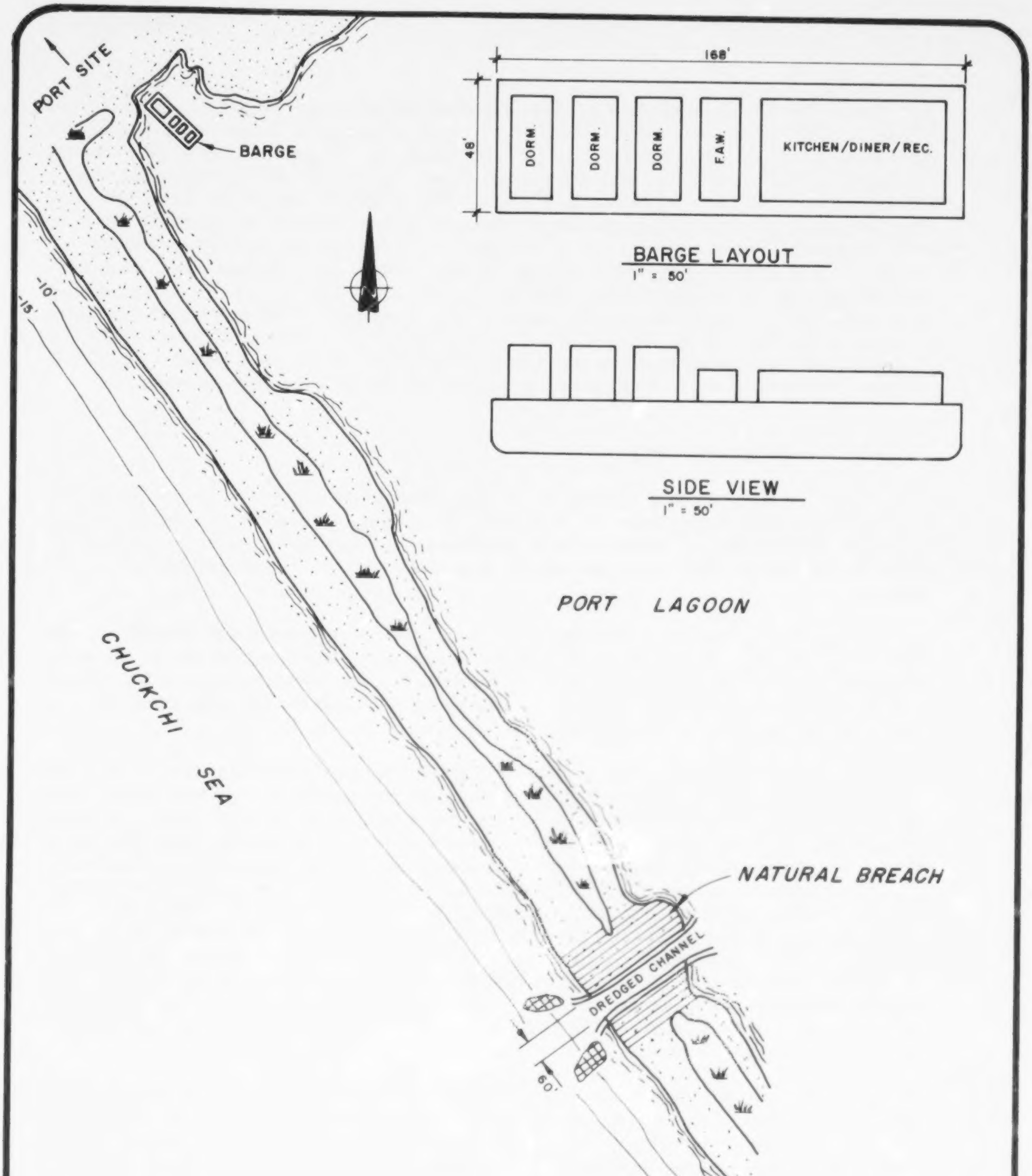

PORT SITE
BARGE
168'
48'
DORM.
DORM.
DORM.
F.A.W.
KITCHEN/DINER/REC.
BARGE LAYOUT
1" = 50'
SIDE VIEW
1" = 50'
PORT LAGOON
CHUCKCHI SEA
NATURAL BREACH
DREDGED CHANNEL
60'
-10'
-15'
-10'
-15'

FIGURE II-18 CONCEPTUAL DIAGRAM OF CONSTRUCTION BARGE IN COASTAL LAGOON

A permanent dockface (in 4.6 m [15 ft] of water) and short causeway would be constructed prior to the 1987 sealift. This facility would be used to off-load ore concentrator and worker housing modules, as well as other mine equipment. During the 1987 sealift the worker housing modules would be the first to be moved to the mine site. These living quarters would be established as quickly as possible for use by construction crews, and later by operating personnel during the project start-up period. In this manner, the additional expense of a larger construction camp would be avoided.

During the summer and early fall of 1987, the concentrate storage building and other port site facilities would be constructed. If the offshore island transfer facility was selected, the modified tanker would be towed to the site and ballasted to the bottom during the 1987 shipping season.

From September to December 1987, the concentrator complex modules at the mine site would be joined and services installed. The facilities would be ready for commissioning (start-up) in December. Once commissioned, operations would commence in February 1988. Construction activities would be completed prior to the 1988 sealift. Construction surplus and equipment would be shipped out at that time.

The first movements of concentrates to market would probably be during the 1988 shipping season, though this would depend on project financing and the status of world lead and zinc markets.

III. ALTERNATIVES INCLUDING THE PROPOSED ACTION

INTRODUCTION

The EIS scoping process, described in Chapter VII, established two important cornerstones for the EIS. First, it identified 12 issues of major concern to be addressed during the EIS process. These issues are described in Chapter I and were the bases for ultimately determining the makeup of the project alternatives. Second, to address these 12 issues, the scoping process identified a full range of options for the project components (Table III-1). Thus, a large number of options was initially considered to address the major technical, environmental and economic issues associated with the project.

Even before the scoping process began, however, certain transportation corridor and port site options in the lowlands of the Wulik and Kivalina drainages were eliminated because of the obvious and significant technical, environmental, and social impacts they would cause. As shown in Figure IV-2, that area is dominated by organic soils (poor foundation conditions), floodplains (annual flooding and unstable banks), patterned ground (severe permafrost conditions), aufeis zones (blockage of drainage structures and transportation systems) and occasional steep slopes (landslides, solifluction* and steep grades).

Environmentally these lowland areas contain important wetlands, waterfowl and shorebird breeding areas, caribou winter range, and fish migration, spawning, rearing and overwintering habitats. From a social standpoint they are the prime subsistence areas for the residents of Kivalina. Also, the location of a transportation corridor and port site in close proximity to the village would have a much greater disruptive effect upon existing lifestyles, an impact the project is striving to avoid.

OPTIONS INITIALLY CONSIDERED

Thirty options and seven suboptions were identified for the 11 project components (Table III-1). Three components (mine, mill site and housing locations) had only one option for each. The ore body, and therefore the mine, was fixed in location. For technical, environmental and economic reasons (e.g., shorter tailings slurry line; natural drainage into the tailings pond; good foundation material; use of waste heat to dry concentrates and heat worker housing), locating the mill, power generation source and worker

---

* Defined in Glossary.

Table III-1

COMPONENT OPTIONS AND SUBOPTIONS IDENTIFIED DURING THE SCOPING PROCESS

Component	Option	Suboption
Mine Location	Fixed	
Tailings Pond Location	North Fork Red Dog Creek Volcano Creek South Fork Red Dog Creek	
Mill Site Location	Dependent upon Tailings Pond Location	
Worker Housing		
° Location	Dependent upon Mill Site Location	
° Type	Townsite Campsite	
Water Supply	Buddy Creek Bons Creek	
Power Generation	Coal Gas Hydropower Diesel	
Transportation		
° Corridor Location	Northern	GCO Route Asikpak Route
	Southern	Western Route Omikviorok Route Kruz Route
	Noatak	
° System	Slurry Pipeline Hovercraft Railroad	
	Road	Winter Only Year-round
Port Site		
° Location	Singoalik Lagoon Tugak Lagoon VABM 17 VABM 28 Hotham Inlet/Kotzebue Sound	
° Transfer Facility	Short Causeway/Lightering Medium Causeway Long Causeway Short Causeway/Offshore Island	

housing together near the tailings pond was necessary for logistical purposes. Since no objections to locating them there were identified, no other options were investigated.

Tailings Pond

Three options were identified (North and South Forks of Red Dog Creek, and Volcano Creek), all within 7 km (4.4 mi) of the ore body (Fig. III-1). Characteristics important for locating these options include capacity, amount of surrounding surface drainage area, structural soundness of dam foundations, minimal impact upon fish, and the ability of adjacent slopes to hold the mill and worker housing facilities as well as stockpiled overburden materials.

Worker Housing Type

Two options were identified, a campsite and a townsite. The campsite would house only workers and support staff, with rotations on a periodic basis to allow employees to return to their homes elsewhere in the region. A townsite would be considerably larger, including families and all the infrastructure necessary to support a larger population.

Water Supply

The inability of wells to supply water, because of permafrost, required use of surface impoundments. Two options, Buddy and Bons Creeks, were identified just south of the headwaters of the South Fork of Red Dog Creek in the Dudd Creek drainage (Fig. II-5). Characteristics important in selecting a water supply include water quality (particularly the ambient concentrations of zinc), impoundment capacity, structural soundness of foundations, stability, minimal fish impact and minimal pumping distance.

Power Generation

Four options were identified; coal, natural gas, hydropower and diesel. The primary factors affecting selection of the power source were energy efficiency and the primary resource availability.

Transportation Corridor Location

Three options were identified (northern, southern and Noatak) between Red Dog Valley and the coast (Fig. III-2). Characteristics important in selecting a corridor include distance, ability to maintain grades suitable for both a railroad and road, suitability of soil conditions, avoidance to the extent possible of major stream crossings, subsistence use areas and cultural sites, impact on Cape Krusenstern National Monument, and impacts on other regional uses.

Northern Corridor

The northern corridor has two suboptions (Fig. III-2). The first would be the GCO route originally suggested by GCO Minerals (drawing No. 1763-0-002). This route would connect GCO's Lik mineral prospect 19 km (12 mi)

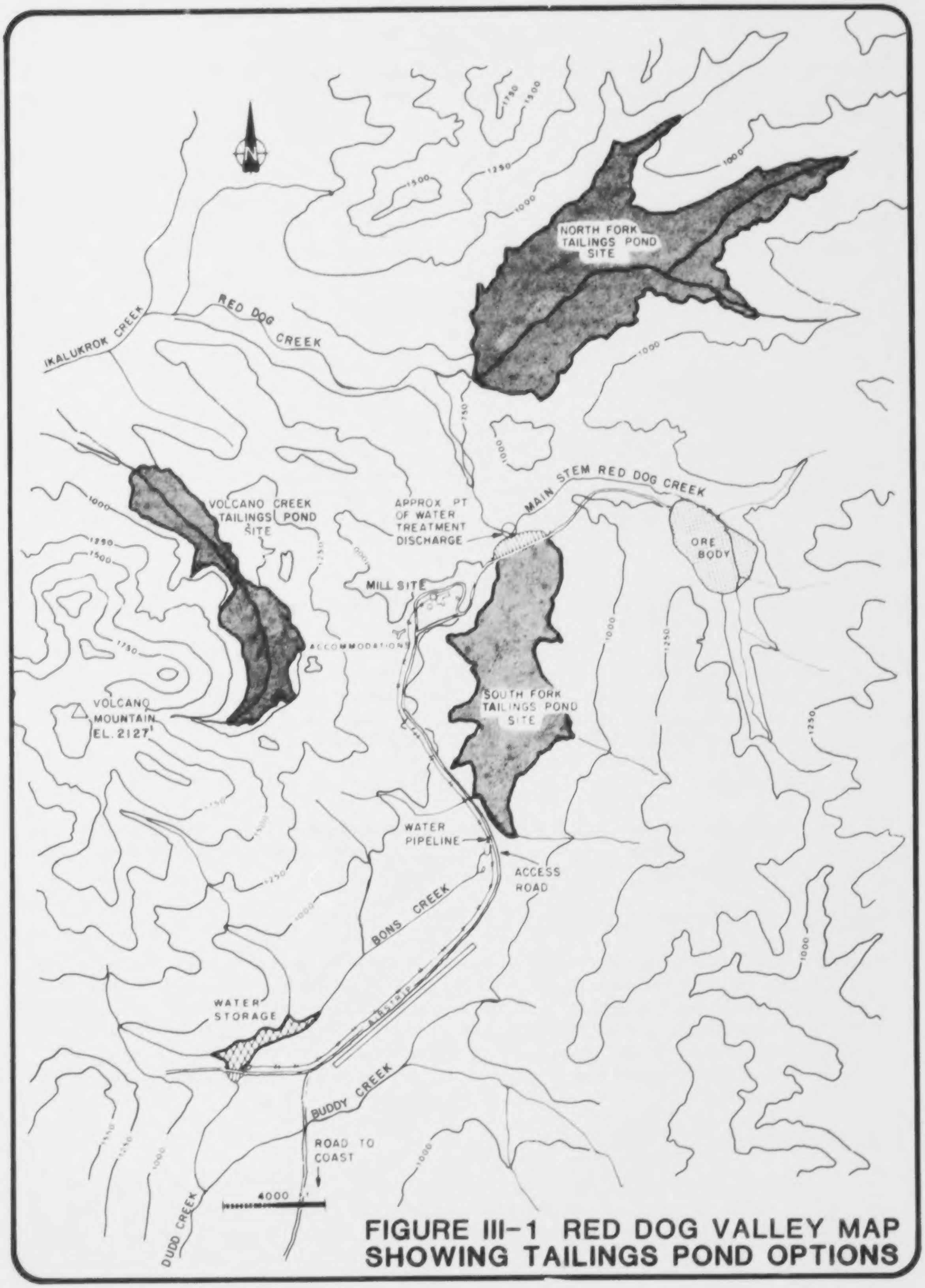

N
NORTH FORK TAILINGS POND SITE
RED DOG CREEK
IKALUKROK CREEK
VOLCANO CREEK TAILINGS POND SITE
APPROX PT OF WATER TREATMENT DISCHARGE
MAIN STEM RED DOG CREEK
ORE BODY
MILL SITE
ACCOMMODATIONS
VOLCANO MOUNTAIN EL. 2127'
SOUTH FORK TAILINGS POND SITE
WATER PIPELINE
ACCESS ROAD
BONS CREEK
AIRSTRIP
WATER STORAGE
BUDDY CREEK
ROAD TO COAST
DUDD CREEK
4000
1750
1500
1250
1000
750

FIGURE III-1 RED DOG VALLEY MAP SHOWING TAILINGS POND OPTIONS

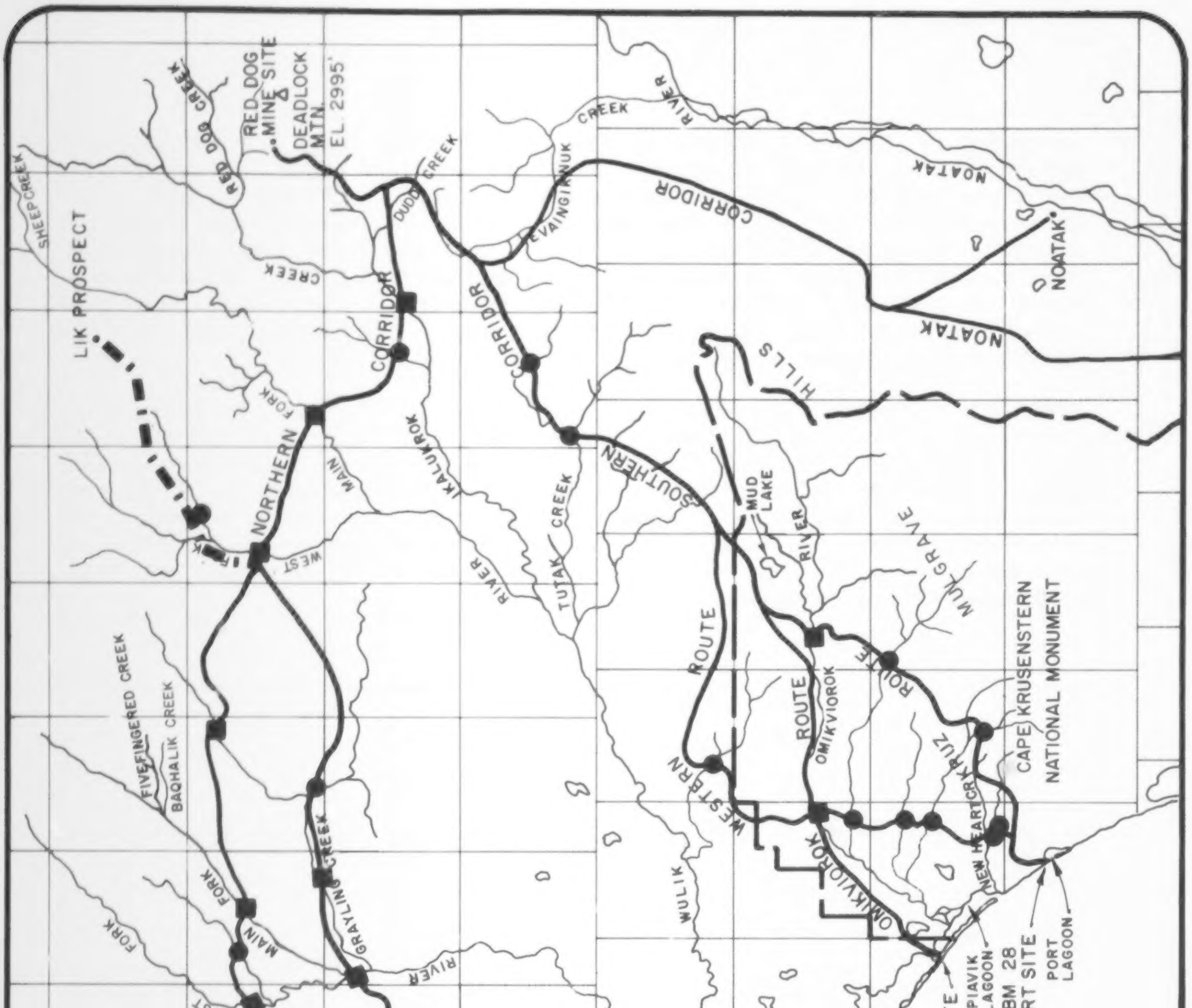

RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
RED DOG CREEK
SHEEP CREEK
LIK PROSPECT
CREEK
DUDD CREEK
EVAINGIRNUK CREEK
RIVER
NOATAK
NOATAK
NOATAK
CORRIDOR
CORRIDOR
CORRIDOR
NORTHERN
SOUTHERN
HILLS
FORK
MAIN
WEST
IKALUKROK
TUTAK CREEK
RIVER
MUD LAKE
RIVER
MULGRAVE
ROUTE
ROUTE
ROUTE
WESTERN
OMIKVIOROK
OMIKVIOROK
CAPE KRUSENSTERN NATIONAL MONUMENT
NEW HEART CREEK
FIVEFINGERED CREEK
BAQHALIK CREEK
FORK
MAIN
FORK
WEST
GRAYLING CREEK
RIVER
WULIK
KIVALINA
GCO ROUTE
ROUTE
RIVER
ASIKPAK
ASIKPAK RIVER
RIVER
SINGOALIK
SINGOALIK
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
VABM 17 PORT SITE
IMIKRUK LAGOON
KIVALINA
SEA
CHUKCHI
KIVALINA LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
SINGOALIK LAGOON
PUSIGRAK LAGOON
SINGOALIK LAGOON PORT SITE
N
6 miles
10 kilometers
LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
MAJOR BRIDGE CROSSING
MINOR BRIDGE CROSSING

FIGURE III-2 RED DOG PROJECT AREA SHOWING TRANSPORTATION ROUTE OPTIONS

northwest of Red Dog Valley to the Chukchi Sea port site at Singoalik Lagoon, 43 km (27 mi) northwest of Kivalina. The route, as modified to reach the Red Dog Valley, would traverse the Wulik and Kivalina Rivers and then cross into and down the Singoalik River drainage to the coast. It would be 133.6 km (83.5 mi) long (Table III-2) and have eight major multi-span bridge crossings (greater than 30.5 m [100 ft]). This route would be similar to the route considered in the Western and Arctic Alaska Transportation Study (WAATS) (Louis Berger & Assoc., 1981) as a route from the Noatak mining district to the coast.

The second northern corridor suboption would be the Asikpak route (Fig. III-2). This route would share a common alignment with the GCO route for the first 46.6 km (29.1 mi) from Red Dog Valley. From the point of divergence at the west fork of the Wulik River, the Asikpak route would proceed westerly similar to the GCO route, but south of it, reaching the coast via the Asikpak River at Tugak Lagoon, 24 km (15 mi) northwest of Kivalina. The route would be 120 km (75 mi) long (Table III-2) and have six major multi-span bridge crossings.

Table III-2

DISTANCES FOR TRANSPORTATION CORRIDOR OPTIONS AND SUBOPTIONS

Transportation Corridor		Total Distance			
		Mine to Port Site		Within Monument	
Option	Suboption	km	mi	km	mi
Northern	GCO	133.6	83.5	NA	
	Asikpak	117.0	73.1	NA	
Southern	Western (VABM 17)	95.8	59.9	15.7	9.8
	Western (VABM 28)	104.8	65.5	27.2	17.0
	Omikviorok (VABM 17)	88.6	55.4	34.6	21.6
	Omikviorok (VABM 28)	97.6	61.0	46.1	28.8
	KRUZ (VABM 28)	89.9	56.2	38.4	24.0
Noatak	To Noatak Village	81.6	51.0	NA	
	To Fish Hatchery	110.4	69.0	NA	

Southern Corridor

The southern corridor has three suboptions, all following the same alignment for approximately the first 48.3 km (30.2 mi) south from Red Dog Valley (Fig. III-2). At that point, just north of the northern boundary of Cape Krusenstern National Monument, the western route suboption would diverge west to within approximately 3.2 km (2 mi) of the Wulik River. It would then turn south into Native-selected, but not yet conveyed, lands still within the Monument, paralleling the Omikviorok River to the VABM 17 port site, or crossing the river and proceeding south to the VABM 28 port site. This route to VABM 17 would be a total of 95.8 km (59.9 mi) long (15.7 km [9.8 mi] within the Monument), and to VABM 28 would be 104.8 km (65.5 mi) long (27.2 km [17.0 mi] within the Monument) (Table III-2). The leg to VABM 17 would cross no major streams. The leg to VABM 28 would have one major multi-span bridge crossing.

The Omikviorok route suboption would also diverge west from the common alignment. Beginning just south of the northern boundary of the Monument, the route would parallel the Omikviorok River to VABM 17, or cross the Omikviorok River and proceed south to VABM 28. This route to VABM 17 would be a total of 88.6 km (55.4 mi) long (34.6 km [21.6 mi] within the Monument), and to VABM 28 would be 97.6 km (61.0 mi) long (46.1 km [28.8 mi] within the Monument) (Table III-2). The leg to VABM 17 would cross no major streams. The leg to VABM 28 would have one major multi-span bridge crossing.

The Kruz route suboption would continue to VABM 28 from the points of divergence from the other suboptions. It would be 89.9 km (56.2 mi) long with 38.4 km (24.0 mi) within the Monument (Table III-2). It would cross the Omikviorok River considerably further upstream than the other two suboptions, and would have one major multi-span bridge crossing.

Noatak Corridor

The Noatak corridor option (Fig. III-2), unlike the others, has not been specifically located by any study. It would proceed south from Red Dog Valley on the same alignment as the southern corridor for approximately 20.8 km (13 mi) and then southeast down Evaingiknuk Creek into the Noatak Valley. It would then proceed south on the west side of the Noatak River, paralleling the river at least as far as the village of Noatak 81.6 km (51 mi). It would probably continue on to the vicinity of the fish hatchery approximately 28.8 km (18 mi) downriver from Noatak (total corridor length of 110.4 km [69 mi]) to reach deeper water for barge transport.

Transportation System

Four options were identified (slurry pipeline, hovercraft, railroad and road). The road had two suboptions: a winter only road and a year-round road. Characteristics important in selecting a transportation system include availability of technology and reliability.

Port Site Locations

Five options were identified (Singoalik Lagoon, Tugak Lagoon, VABM 17, VABM 28, and an unspecified location in Hotham Inlet/Kotzebue Sound) (Fig. III-2). Each site was specifically associated with one transportation corridor suboption except for VABM 17, which could be the terminus of either the Western or Omikviorok southern route suboptions, and VABM 28, which could be the terminous of all three southern route suboptions. The Hotham Inlet/Kotzebue Sound site would serve as the loading point for barges moving down the Noatak River.

Characteristics important for locating a port site include suitability of soils for construction, distance to deep water, suitability for expansion, and suitability for other regional uses. Selection of a port site was, obviously, closely associated with the selection of a transportation corridor.

Transfer Facility

Four options were identified (short causeway/lightering, medium causeway, long causeway and short causeway/offshore island). The short causeway/lightering option would involve a 122 m (400 ft) earth-filled dock structure with stone protection facing. Concentrates would be transferred to bulk carriers anchored offshore using two large barge lighters moved by tugs. The medium and long causeways would be earth-filled structures approximately 1,219 m (4,000 ft) and 2,438 to 4,267 m (8,000 to 14,000 ft), respectively, that would allow loading of concentrates directly to ships in deeper water. The short causeway/offshore island option would involve the same 122 m (400 ft) filled dock structure and lightering as in the short causeway/lightering option, but the concentrates would be transferred by one smaller, self-powered lighter to a large ballasted ship resting on the sea bottom at sufficient depth to directly load the bulk carriers. The ballasted ship would serve as a docking platform and concentrate storage facility.

Characteristics important for selecting these options include distance to deep water, longshore sediment transport, fish and marine mammal movements, reliability and seasonal shipping constraints.

OPTIONS SCREENING PROCESS

The options screening process was conducted in two steps. First, all of the 30 options and seven suboptions identified during the scoping process (as described previously) were initially reviewed to eliminate from further consideration those options which were clearly unreasonable or infeasible primarily for environmental or technical reasons. In the second step, all remaining options and suboptions not eliminated in step one were individually evaluated in detail from the perspective of each resource or technical discipline (e.g., water quality, subsistence, technical feasibility, etc.). These two steps are described below.

Initial Options Evaluation

Each component option and suboption identified during the scoping process was individually reviewed from environmental and technical perspectives. If an option (or suboption) was environmentally and technically reasonable and feasible, it was retained for further detailed analysis. If, however, the option was determined to be unreasonable or infeasible on environmental or technical grounds, and if other options retained for that component adequately addressed the 12 issues, it was eliminated. Table III-3 identifies the 11 options and one suboption eliminated during this initial options review, and outlines the major reasons why each was eliminated. Table III-4 summarizes the results of the initial options review process and shows those options and suboptions retained and eliminated.

Note that as a result of this initial options review two additional components, i.e., type of worker housing and power generation, had options eliminated such that only one option remained for each. Thus, a total of five components at this stage of the option screening process had only one option left while the six other components still had two or more options each.

Remaining Options Evaluation

Each of the remaining 14 options and six suboptions (for the six components having two or more options) was then individually evaluated in detail from the perspective of each resource or technical discipline (e.g., water quality, subsistence, technical feasibility, etc.). For each discipline, a specific set of "options screening criteria" was developed against which each option (and suboption) was screened to identify potential impacts upon that discipline. Table III-5 lists these individual discipline screening criteria.

For example, when evaluating the two remaining tailings pond location options from the water quality perspective (Table III-5) five screening criteria were used: stream diversion requirements, spill hazard, downstream impacts, capacity and reclamation difficulty.

For each discipline, once each option for a specific component had been evaluated against all screening criteria, each option was then compared to all other options for that component and a "relative level of potential impact" was assigned. It is important to understand that potential impacts were assigned relative to the other options for each project component. The relative levels of potential impact were low, moderate and high. For example, using the water quality discipline and the tailings pond location component, both remaining tailings pond options (North Fork and South Fork of Red Dog Creek) were first evaluated individually against the option screening criteria to determine what the stream diversion requirements would be, what was the spill hazard, etc. When this was completed for both the North Fork and South Fork options separately, the two were compared on the basis of the screening criteria and a relative level of potential impact was assigned to each option. In this case (i.e., for water quality), the relative level of potential impact for North Fork was "high" while that for South Fork was "low". Thus, from a water quality perspective, the South Fork of Red Dog Creek had the relatively lower level of potential impact for location of a tailings pond.

Table III-3

MAJOR REASONS FOR ELIMINATION OF INDIVIDUAL OPTIONS AND SUBOPTIONS DURING INITIAL OPTIONS REVIEW

Component	Option or Suboption	Major Reasons for Elimination
Tailings Pond	Volcano Creek	° Two dam structures required ° Higher risk of embankment failure ° Limited storage capacity ° Major pumping required ° Difficult mitigation/reclamation ° Insufficient overburden storage area ° Least dilution/mixing of runoff, seepage & spills ° Short distance to fish populations in Ikalukrok Creek if spill occurred
Worker Housing	Townsite	° Substantially greater infrastructure required (water, sewer, housing, etc.) ° Adverse to local autonomy ° Less adaptable to traditional regional lifestyles ° Fewer local hire opportunities ° Competition with subsistence activities ° Greater land area impact ° Increased site runoff problems ° Greater impacts on fish and wildlife (increased hunting & fishing; human/wildlife contacts; etc.)
Power Generation	Coal	° No nearby, operating source of supply ° Low energy efficiency ° Scrubber and cooling wastewater disposal impacts ° Air pollutant emissions
	Natural Gas	° No nearby, operating source of supply ° Low temperature pipeline technology required (if liquified gas was considered) ° Major additional impacts if pipeline constructed
	Hydropower	° No nearby, operating source of supply ° No year-round sites identified in area ° Construction of dam & impoundment would create additional major environmental impacts

Table III-3
(Continued)
MAJOR REASONS FOR ELIMINATION OF INDIVIDUAL OPTIONS AND SUBOPTIONS DURING INITIAL OPTIONS REVIEW

Component	Option or Suboption	Major Reasons for Elimination
Transportation Corridor and Port Site	Noatak Corridor & Hotham Inlet	° Limited barging season would require significant dredging of Noatak River ° Substantial weather and low water problems ° Barge to bulk carrier transfer point would still have to be constructed in Hotham Inlet/Kotzebue Sound ° Corridor would cross many lowlands with substantial permafrost and wetlands problems ° Many stream crossings with associated impacts on water quality and fish
Transportation System	Slurry Pipeline	° Cold weather slurry lines not yet feasible ° High spill hazard ° Slurry water disposal problems ° Waste heat from power generation couldn't be used to dry concentrates
	Hovercraft	° Units large enough to efficiently haul concentrates not yet available ° Excessive fuel consumption ° Noise levels reach 105 db ° Substantial disturbance to wildlife
	Winter Road	° Unpredictability of snow availability ° Annual construction of ice/snow bridges at river crossings pose erosion problems ° Greater spill hazards at river crossings ° Increased disturbance to wintering caribou ° Less flexibility for other regional uses
Transfer Facility	Medium Causeway	° Possible significant impacts on sediment transport causing erosion & lagoon breaching ° Impacts on fish and marine mammal movements ° Winter and breakup ice problems ° Greater disruption of marine benthos ° Substantial armor rock needed - no local source available
	Long Causeway	° Same problems as for medium causeway - but of greater magnitude

Table III-4

OPTIONS AND SUBOPTIONS ELIMINATED OR RETAINED FOR FURTHER ANALYSIS DURING INITIAL OPTIONS REVIEW

Component	Retained		Eliminated	
	Option	Suboption	Option	Suboption
Mine Location	Fixed[1]			
Tailings Pond Location	North Fork R.D. Creek South Fork R.D. Creek		Volcano Creek	
Mill Site Location	Dependent upon Tailings Pond Location			
Worker Housing				
• Location	Dependent upon Mill Site Location			
• Type	Campsite[1]		Townsite	
Water Supply	Buddy Creek Bons Creek			
Power Generation	Diesel[1]		Coal Natural Gas Hydropower	
Transportation				
• Corridor Location	Northern	GCO Route Asikpak Route	Noatak	
	Southern	Western Route Omikviorok Route Kruz Route		
• System	Railroad		Slurry Pipeline	
			Hovercraft	
	Road	Year-round	Road	Winter Only
Port Site				
• Location	Singoalik Lagoon Tugak Lagoon VABM 17 VABM 28		Hotham Inlet/ Kotzebue Sound	
• Transfer Facility	Short Causeway/ Lightering Short Causeway/ Offshore Island		Medium Causeway Long Causeway	

---

[1] Sole option remaining for that component.

Table III-5

INDIVIDUAL DISCIPLINE OPTIONS SCREENING CRITERIA

DISCIPLINE	OPTIONS SCREENING CRITERIA
Water Quality	Tailings Pond Location: Stream diversion requirements Spill hazard Downstream impacts Capacity Reclamation difficulty
	Transportation Corridor Location: Spill hazard Reclamation difficulty Sediment production from road surface, cuts, fills, sideslopes and road crossings
	Transportation System: Spill hazard Sediment production and control
	Port Site and Transfer Facility: Impact on seawater quality Impact on lagoons Spill hazard
Air Quality	Air pollutant emission rates
	Power plant plume impact areas
	Transportation system dust generation
Coastal Geologic Processes	Net sediment transport
	Erosion of port facilities
	Breaching of adjacent lagoons
Vegetation	Direct vegetation loss
	Indirect loss from dust, foot or vehicular traffic
	Relative functions of wetlands
Freshwater Biology	Quality and quantity of habitat affected
	Quality/quantity of trophic* resources

---

* Defined in Glossary.

Table III-5
(continued)

INDIVIDUAL DISCIPLINE OPTIONS SCREENING CRITERIA

DISCIPLINE	OPTIONS SCREENING CRITERIA
Fish	Fish present or absent Resource value in terms of spawning, rearing, overwintering and migration Recreation and access Number of major stream crossings
Wildlife	Direct habitat loss Indirect habitat loss due to noise, other disturbance or human contacts Affect on animal movements
Marine Biology	Quality and quantity of benthic habitat affected Disruption of sedimentation patterns Disruption of organism movements Spill hazard
Socioeconomics	Impact on community population growth and infrastructure needs Impact on autonomy of social and governing institutions Ratio of nonresident/resident hire Resident employment and income gains Project compatibility with continuance of subsistence culture and traditional lifestyle
Subsistence	Interference with subsistence harvest activities Compatibility of project employment with subsistence harvest cycles Increased nonresident harvest of subsistence resources Effects of mine employment on subsistence efficiency and success.

Table III-5
(continued)

INDIVIDUAL DISCIPLINE OPTIONS SCREENING CRITERIA

DISCIPLINE	OPTIONS SCREENING CRITERIA
Cultural Resources	Direct impact Indirect impact from erosion, foot or vehicular traffic, accessibility, unauthorized artifact collection, etc. Significance based on National Register of Historic Places Criteria for Evaluation (36 CFR Part 60.4)
Recreation	Impacts on existing recreation Access
Regional Use	Flexibility for other regional uses Size and location of component site Preclusion of other users or uses
Krusenstern Impact	Beach erosion at Cape Krusenstern Archeological site protection Aesthetic degradation (visual, sound, wilderness character) Access
Technical Feasibility	Availability of adequate construction technology Relative difficulty of design, construction and operation
Economic Feasibility	Cost of construction Operation costs Reclamation costs

In addition to the water quality discipline, the options screening criteria for every other discipline were applied in a similar manner and a relative level of potential impact was assigned to each option for every remaining component. The results of this process, including the assigned relative levels of potential impact, are summarized in Table III-6 for each discipline where a reasonable difference existed between options.

Where screening analyses comments shown in Table III-6 were based upon published material or documentation (letters, etc.) developed for the Red Dog project, a lower case citation letter in parenthesis (e.g., "(c)") is shown that corresponds to the proper citation listed on a separate page that follows the table. Where no citation letter is shown, the comment represents best professional judgement based upon past experience, discussion with others, visits to the project area or calculations developed specifically for this options screening process.

It should be noted in Table III-6C and III-6D that the suboptions for the northern and southern transportation corridors, respectively, were compared only against the other suboption(s) for each of those corridors (i.e., the GCO route and the Asikpak route were compared only against each other for the northern corridor, and the Western, Omikviorok and Kruz routes were compared only among themselves for the southern corridor). This was done to specifically address the Title XI requirement that alternate routes around the Monument be fully evaluated in the EIS process. By comparing each corridor's routes only among themselves, the best route for each corridor was identified, thus guaranteeing that each corridor would be considered during the evaluation of alternatives process and be included in the alternatives for formal public review in the draft EIS.

In the next step of the process, the levels of potential impact for all disciplines (as shown in Table III-6) were grouped for each option. This provided a combined picture of the individual levels of potential impact (Table III-7).

A perusal of Table III-7 shows that for most options the distribution of the relative levels of potential impact made determination of an overall relative level of potential impact for a specific option fairly straightforward. These overall relative levels of potential impact are shown in Table III-8.

The final step of the option screening process was to select the best option for each of the remaining six components. This was done by using Table III-8 to determine the option for each component which showed the lowest level of potential impact (the lower the potential level of impact, the better the option). That option was then selected unless one of the other options for that component addressed one or more of the 12 issues in a significantly more favorable manner.

For three of the six remaining components, selection of the best option was relatively straightforward. For the tailings pond component the South Fork of Red Dog Creek (Table III-8) was clearly the best location, as was Bons Creek for the water supply. For the southern transportation corridor and port site the Kruz route to VABM 28 was selected.

Table III-6A

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

TAILINGS POND LOCATION

	NORTH FORK RED DOG CREEK				SOUTH FORK RED DOG CREEK			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Water Quality	Larger capacity.(l)	Larger drainage area. Spill closer to Ikalukrok Creek.	Higher risk of diversion system failure.	High	Smaller drainage area. Lower risk of diversion system failure. Spill further from Ikalukrok Creek.	Smaller capacity.(l)		Low
Vegetation			Direct loss of 468 ha (1,157 ac). Greater wetlands impact.	High		Direct loss of 237 ha (585 ac). Lesser wetlands impact.		Moderate
Freshwater Biology			Best quality habitat lost. Greater quantity habitat lost. Greater trophic resources lost.	High	Poor quality habitat lost. Lesser quantity habitat lost. Fewer trophic resources lost.			Low
Fish			Migration, spawning & rearing habitat lost.(d) Fish present.(d)	High	No migration, spawning & rearing habitat lost.(d) Fish absent.(d)			Low
Wildlife			Greater direct habitat loss.(c) Greater indirect habitat loss. Greater effect on animal movements.	High	Lesser direct habitat loss.(c) Lesser indirect habitat loss. Lesser effect on animal movements.			Low
Technical Feasibility			Greater thaw bulb & stability problems with larger pond.(n) Larger dam to build.(c)	High	Smaller thaw bulb & stability problems with smaller pond.(n) Smaller dam to build.(c)			Low
Economic Feasibility			25% greater cost.(l)	High	25% lower cost.(l)			Low

---

[1] Includes only disciplines having a reasonable difference in impacts between options.
(a) etc. See reference list following Table III-6H.

Table III-6B

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

WATER SUPPLY

	BUDDY CREEK				BONS CREEK			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Vegetation	Direct loss of >40 ha (>100 ac).			Low	Direct loss of 31 ha (76 ac).			Low
Technical Feasibility		Greater dam height.(c) Lower capacity.(c) Longer access road.(c)		Moderate	Lower dam height.(c) Higher capacity.(c) Shorter access road.(c)			Low
Economic Feasibility			Construction cost approximately $9.3M.(l)	High	Construction cost approximately $1.9M.(l)			Low

---

[1] Includes only disciplines having a reasonable difference in impacts between options.
(a) etc. See reference list following Table III-6H.

Table III-6C

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

NORTHERN TRANSPORTATION CORRIDOR

	GCO ROUTE				ASIKPAK ROUTE			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Vegetation		Direct loss of 293 ha (723 ac) (not including borrow sites).(l)		Moderate		Direct loss of 257 ha (634 ac) (not including borrow sites).(l)		Moderate
Fish			Impacts on spawning, rearing, overwintering and migration from crossings of important streams, particularly the upper Kivalina River and tributaries.(d, i, j, p) Impacts from access to important spawning areas.	High			Impacts on spawning, rearing, overwintering and migration from crossings of important streams, particularly Grayling Creek and Kivalina River.(d, i, j, p) Impacts from access to important spawning areas.	
Wildlife		Direct habitat loss of 293 ha (723 ac) (not including borrow sites).(l)		Moderate		Direct habitat loss of 257 ha (634 ac) (not including borrow sites).(l)		Moderate
Subsistence		Lesser conflict with subsistence use areas.(a) Lesser nonresident harvest of subsistence resources.(a)		Moderate			Greater conflict with subsistence use areas.(a) Greater nonresident harvest of subsistence resources.(a)	High
Cultural Resources[2]			Potential indirect impacts on 12 sites. (f)	High	No sites along route.(d, e)			Low

---

[1] Includes only disciplines having a reasonable difference in impacts between options.

[2] Does not address common alignment segment in eastern portion of northern corridor.

(a) etc. See reference list following Table III-6H.

Table III-6C
(Continued)

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

NORTHERN TRANSPORTATION CORRIDOR

	GCO ROUTE				ASIKPAK ROUTE			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Regional Use		More difficult to access from Kivalina.		Moderate	Easier to access from Kivalina.			Low
Technical Feasibility			65% of route moderately difficult or difficult to construct.(c) Two more major bridge crossings.(m)	High		41% of route moderately difficult or difficult to construct.(c) Two fewer major bridge crossings.(m)		Moderate
Economic Feasibility			Construction cost approximately $128M.(c)	High			Construction cost approximately $126M.(c)	High

[1] Includes only disciplines having a reasonable difference in impacts between options.

(a) etc. See reference list following Table III-6H.

Table III-6D

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

SOUTHERN TRANSPORTATION CORRIDOR[2]

	WESTERN ROUTE				OMIKIVOROK ROUTE				KRUZ ROUTE			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total	Low	Moderate	High	Total
Water Quality		Close to Wulik and crosses Omikviorok: spill hazard; sedimentation problems		Moderate		Parallels and crosses the Omikvierok: spill hazard; sedimentation problems.		Moderate	Minor crossings of upper Omikviorok: less spill hazard; less sedimentation.			Low
Vegetation			Direct loss of 230 ha (568 ac).(l) Most impact to productive wetlands.	High		Direct loss of 214 ha (529 ac).(l) Moderate impact to productive wetlands.		Moderate	Direct loss of 197 ha (487 ac).(l) Least impact to productive wetlands.			Low
Freshwater Biology		Close to Wulik and crosses Omikviorok: risk of disruption to habitat and trophic resources.		Moderate			Adjacent to and crosses Omikviorok: greatest risk of disruption to habitat and trophic resources.	High	One major bridge crossing of upper reaches of Omikviorok: least risk of disruption to habitat and trophic resources.			Low
Fish			Close to Wulik and crosses Omikviorok: spill and sedimentation risks. (d,l,j) Increased access to fish populations.	High			Adjacent to and crosses Omikviorok: spill and sedimentation risks. (d,l,j) Increased access to fish populations.	High		One major bridge crossing of upper reaches of Omikviorok: fewer spill and sedimentation risks. (d,l,j) Less access to fish populations.		Moderate
Wildlife			Most direct habitat loss.(l) Most indirect habitat loss.	High		Moderate direct habitat loss.(l) Moderate indirect habitat loss.		Moderate	Least direct habitat loss.(l) Least indirect habitat loss.			Low

Table III-6D
(Continued)

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

SOUTHERN TRANSPORTATION CORRIDOR

	WESTERN ROUTE				OMIKVIOROK ROUTE				KRUZ ROUTE			
Discipline	Low	Moderate	High	Total	Low	Moderate	High	Total	Low	Moderate	High	Total
Subsistence		Some interference with harvest activities. Some increase in nonresident harvest.		Moderate		Some interference with harvest activities. Some increase in nonresident harvest.		Moderate	Least interference with harvest activities. Least increase in nonresident harvest.			Low
Cultural Resources[3]		Potential indirect impacts on four sites.(f,g)		Moderate		Potential indirect impacts on three sites.(f,g)		Moderate			Potential indirect impacts on six sites.(f,g)	High
Krusenstern Impact	Least increase in access and traffic in Monument.(c) Two of the four archeological sites in the Monument. (f,g)			Low		Moderate increase in access and traffic in Monument.(c) All three archeological sites in the Monument. (f,g)		Moderate			Most increased in access and traffic in Monument.(c) All six archeological sites in Monument.(f,g)	High
Technical Feasibility		23% of route moderately difficult or difficult to construct.(l) One major multi-span bridge crossing.(c)		Moderate		25% of route moderately difficult or difficult to construct.(l) One major multi-span bridge crossing.(c)		Moderate	19% of route moderately difficult or difficult to construct.(l)	One major multi-span bridge crossing.(l)		Low
Economic Feasibility			Construction cost approximately $98M.(l)	High		Construction cost approximately $83M.(l)		Moderate	Construction cost approximately $75M. (l)			Low

[1] Includes only disciplines having a reasonable difference in impacts between options.

[2] The Western, Omikviorok and Kruz routes are compared using the alignments to the environmentally and technically superior VABM 28 port site option.

[3] Does not address common alignment segment in northern portion of southern corridor.

(a) etc. See reference list following Table III-6H.

Table III-6E

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

TRANSPORTATION SYSTEM

	RAILROAD				YEAR-ROUND ROAD			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Water Quality		Greater spill hazard. Lower sedimentation hazard.		Moderate	Lower spill hazard.		Higher sedimenta-hazard.	High
Air Quality		Lower dust generation.		Moderate			Higher dust generation.	High
Vegetation		Lesser loss from dust. Fewer impacts from poorer access.		Moderate			Greater loss from dust. Greater loss from better access.	High
Freshwater Biology		Fewer impacts at stream crossings.		Moderate			Greater impacts at stream crossings.	High
Fish		Lower sedimentation hazard. Greater spill hazard. Poorer access.		Moderate	Lower spill hazard.		Higher sedimentation hazard. Better access.	High
Wildlife		Lower indirect habitat loss. Fewer effects on animal movements.		Moderate			Higher indirect habitat loss. Greater effects on animal movements.	High

Table III-6E

(Continued)

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

TRANSPORTATION SYSTEM

	RAILROAD				YEAR-ROUND ROAD			
Discipline	Low	Moderate	High	Total	Low	Moderate	High	Total
Subsistence	Lower nonresident harvest of subsistence resources.			Low			Higher nonresident harvest of subsistence resources.	High
Cultural Resources		Fewer indirect impacts due to poorer access.		Moderate			Greater indirect impacts due to better access.	High
Recreation			Poorer access.	High	Better access.			Low
Regional Use		Less adaptability to other uses.		Moderate	Most adaptability to other uses.			Low
Krusenstern Impact		Poorer access to Monument.		Moderate			Better access to Monument.	High
Technical Feasibility			Cannot transport large mine area facilities modules.(c)	High	Can transport large mine area facilities modules.(c)			Low
Economic Feasibility			High capital costs ($20M to $50M greater than road[2]).(c)	High		Lower capital costs ($20M to 50M less than R.R.[2]).(c)		Moderate

---

[1] Includes only disciplines having a reasonable difference in impacts between options.

[2] For Kruz route suboption.

(a) etc. See reference list following Table III-6H.

Table III-6F

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

PORT SITE LOCATION (NORTHERN CORRIDOR)

	SINGOALIK LAGOON				TUGAK LAGOON			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Coastal Geologic Processes	Low net sediment transport.(o)			Low	Low net sediment transport.(o)			Low
Fish		Herring present offshore.(d)	Anadromous* fish present in lagoon. (d;l)	High	Anadromous fish absent from lagoon.(d,l)	Herring present offshore.(d)		Low
Wildlife	Lesser interference with coastal animal movements.			Low	Greater interference with coastal animal movements.			Moderate
Marine Biology			Marine biota in lagoon.	High	Few marine biota in lagoon.			Low
Subsistence	Some interference with subsistence harvest areas.(a)			Low			Greater interference with marine mammal and waterfowl harvest areas.(a)	High
Cultural Resources	Facility design should prevent impact to sod house.(f)			Low	Facility design should prevent impact to eroding cabin site.(f)			Low
Regional Use		Potential private GCO mill site claims.		Moderate		Potential NANA private lands.		Moderate

---

[1] Includes only disciplines having a reasonable difference in impacts between options.

(a) etc. See reference list following Table III-6H.

* Defined in Glossary.

Table III-6G

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

PORT SITE LOCATION (SOUTHERN CORRIDOR)

	VABM 17				VABM 28			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Water Quality			High lagoon sedimentation risk from construction.	High		Moderate lagoon sedimentation risk from construction.		Moderate
Coastal Geologic Processes	Possible erosion of port facilities.	Moderate net sediment transport. (h,k,o)	Severe storm(s) could breach Imikruk or Iplavik Lagoons.	High	Possible erosion of port facilities.	Moderate net sediment transport. (h,k,o) Severe storm(s) could breach Port Lagoon.		Moderate
Fish			Anadromous fish present in lagoon. (d, l)	High	Anadromous fish absent from lagoon. (d, l)			Low
Wildlife			Greater indirect waterfowl habitat loss.	High	Lesser indirect waterfowl habitat loss.			Low
Marine Biology			Marine biota in both lagoons.	High	Few marine biota in lagoon.			Low
Subsistence	Some interference with subsistence harvest areas.(a)			Low		Greater interference with marine mammal harvest area.(a)		Moderate
Cultural Resources	Facility design should prevent impact to one cabin and two grave sites.(f)			Low	Facility design should prevent impact to reindeer herding site.(d,e,g)			Low

Table III-6G

(Continued)

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

PORT SITE LOCATION (SOUTHERN CORRIDOR)

	VABM 17				VABM 28			
Discipline	Low	Moderate	High	Total	Low	Moderate	High	Total
Regional Use		NANA private land.	Small size. Poor expansion potential.(c)	High	Adequate size. Good expansion potential.(c)	NANA private land.		Low
Krusenstern Impacts		Some impact on littoral sediment drift, but probability of impact on beach ridges not significant.(o) Lower aesthetic impact of site adjacent to Monument. Less access to Monument.(c)		Moderate		Some impact on littoral sediment drift, but probability of impact on beach ridges not significant.(o)	Higher aesthetic impacts of site surrounded by Monument. Greater access to Monument.(c)	High
Technical Feasibility		Bedrock not present to 18.9 m (62 ft).(l)	Greater ice content in soils.(l)	Moderate	Bedrock present about 16.8 m (55 ft).(l)	Lower ice content in soils.(l)		Low

---

[1] Includes only disciplines having a reasonable difference in impacts between options.

(a) etc. See reference list following Table III-6H.

Table III-6H

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

TRANSFER FACILITY

	SHORT CAUSEWAY/LIGHTERING				SHORT CAUSEWAY/OFFSHORE ISLAND			
Discipline[1]	Low	Moderate	High	Total	Low	Moderate	High	Total
Water Quality	Less seabed disturbance.		Greater spill risk from many in-sea fuel/concentrate transfers between unstable transfer platforms. Greater spill risk from fuel lightered to shore.(l) Greater risk of weather impacting lightering or transfers. (l)	High	Minor risk of weather impacting lightering or transfers.(l)	More seabed disturbance. Significantly fewer in-sea concentrate transfers between unstable transfer platforms. Lower spill risk from fuel transported to shore via pipeline.(l)		Moderate
Coastal Geologic Processes	Some sediment transport restriction.(h,k,o) Possible erosion of port facilities and lagoon breaching.			Low	Some sediment transport restriction.(h,k,o) Possible erosion of port facilities and lagoon breaching.			Low
Fish	Some movement interference.(d)		Greater spill risk from many in-sea fuel/concentrate transfers between unstable transfer platforms.(b, m) Greater spill risk from fuel lightered to shore.(m)	High	Some movement interference.(d) Small loss/conversion of habitat under ship.(d)	Significantly fewer in-sea concentrate transfers between unstable transfer platforms.(b, m) Lower spill risk from fuel transported to ship via pipeline.(m)		Moderate
Wildlife	Little direct habitat loss.(l) Little indirect habitat loss. Few effects on animal movements.			Low		Greater direct habitat loss.(l) Greater indirect habitat loss. Greater effects on animal movements.		Moderate

Table III-6H

(Continued)

SUMMARY OF OPTIONS SCREENING CRITERIA ANALYSES SHOWING RELATIVE LEVELS OF POTENTIAL IMPACT

TRANSFER FACILITY

	SHORT CAUSEWAY/LIGHTERING				SHORT CAUSEWAY/OFFSHORE ISLAND			
Discipline	Low	Moderate	High	Total	Low	Moderate	High	Total
Marine Biology	Low bottom disturbance. Some movement interference.	Moderate lagoon disturbance. Greater spill risk from in-sea concentrate transfers and lightering of fuel		Moderate	Some movement interference. Lesser spill risk from fewer in-sea concentrate transfers and use of fuel pipeline.	Greater bottom disturbance. Moderate lagoon disturbance.		Low
Regional Use		Less flexibility for other users.		Moderate	Greater flexibility for other users.			Low
Krusenstern Impacts	Some impact on littoral sediment drift, but probability of impact on beach ridges is not significant.(o) Some aesthetic impact to coastline.			Low	Some impact on littoral sediment drift, but probability of impact on beach ridges is not significant.(o)	Greater aesthetic impact on coastline from large ballasted tanker.		Moderate
Technical Feasibility	No ship or pipeline ice/scour problems.	Two concentrate transfers.(l)	Two large tug/barge lighters.(l) More transfers between unstable platforms.(l) Fuel lightered to shore.(l)	High		Fuel piped to shore.(l) Fewer transfers between unstable platforms.(l)	One self-propelled/unloading barge.(l) Ballasted ship and pipeline ice/scour problems. Three concentrate transfers.(l)	High
Economic Feasibility			Construction costs approximately $74M. (l) Annual operating costs $1.4M greater. (l)	High	Construction costs approximately $55M. (l) Annual operating costs $1.4M less. (l)			Low

---

[1] Includes only disciplines having a reasonable difference in impacts between options.

(a) etc. See reference list following this table.

Table III-6 References[1]

(a) Braund & Associates, 1983
(b) Cominco Alaska, Inc., 1983a
(c) Cominco Alaska, Inc., 1983c
(d) Dames & Moore, 1983a
(e) Hall, 1982a
(f) Hall, 1983a
(g) Hall, Pers. Comm., 1983b
(h) Hopkins, 1977
(i) Houghton, Pers. Comm., 1983
(j) LGL Ecological Research Associates, 1980
(k) Moore, 1966
(l) Noah, Pers. Comm., 1983
(m) Rae, Pers. Comm., 1983
(n) Tsytovich, 1977
(o) Woodward-Ciyde Consultants, 1983
(p) Alt, Pers. Comm., 1983

---

[1] Full references found in Chapter XI (References Cited).

Table III-7

GROUPED RELATIVE LEVELS OF POTENTIAL IMPACT FOR INDIVIDUAL DISCIPLINES[1]

Component Option Suboption	Relative Level of Potential Impact[2] Low	 Moderate	 High
Tailings Pond Location			
North Fork Red Dog Creek			Water Quality Vegetation Freshwater Biology Fish Wildlife Technical Feasibility Economic Feasibility
South Fork Red Dog Creek	Water Quality Freshwater Biology Fish Wildlife Technical Feasibility Economic Feasibility	Vegetation	
Water Supply			
Buddy Creek	Vegetation	Technical Feasibility	Economic Feasibility
Bons Creek	Vegetation Technical Feasibility Economic Feasibility		
Transportation Corridor[3]			
Northern Corridor			
GCO Route		Subsistence Regional Use	Cultural Resources Technical Feasibility
Asikpak Route	Cultural Resources Regional Use	Technical Feasibility	Subsistence
Southern Corridor[3]			
Western Route	Krusenstern Impact	Water Quality Freshwater Biology Subsistence Cultural Resources Technical Feasibility	Vegetation Fish Wildlife Economic Feasibility
Omikviorok Route		Water Quality Vegetation Wildlife Subsistence Cultural Resources Krusenstern Impact Technical Feasibility Economic Feasibility	Freshwater Biology Fish

Table III-7

(Continued)

GROUPED RELATIVE LEVELS OF POTENTIAL IMPACT FOR INDIVIDUAL DISCIPLINES[1]

Component Option Suboption	Relative Level of Potential Impact[2]		
	Low	Moderate	High
Kruz Route	Water Quality Vegetation Freshwater Biology Wildlife Subsistence Technical Feasibility Economic Feasibility	Fish	Cultural Resources Krusenstern Impact
Transportation System			
Railroad	Subsistence	Water Quality Air Quality Vegetation Freshwater Biology Fish Wildlife Cultural Resources Regional Use Krusenstern Impact	Recreation Technical Feasibility Economic Feasibility
Road	Recreation Regional Use Technical Feasibility	Economic Feasibility	Water Quality Air Quality Vegetation Freshwater Biology Fish Wildlife Subsistence Cultural Resources Krusenstern Impact
Port Site Location[4]			
Singoalik Lagoon	Wildlife Subsistence		Fish Marine Biology
Tugak Lagoon	Fish Marine Biology	Wildlife	Subsistence
VABM 17	Subsistence	Krusenstern Impact Technical Feasibility	Water Quality Coastal Processes Fish Wildlife Marine Biology Regional Use
VABM 28	Fish Wildlife Marine Biology Regional Use Technical Feasibility	Water Quality Coastal Processes Subsistance	Krusenstern Impact

Table III-7

(Continued)

GROUPED RELATIVE LEVELS OF POTENTIAL IMPACT FOR INDIVIDUAL DISCIPLINES[1]

Component Option Suboption	Relative Level of Potential Impact[2] Low	Moderate	High
Transfer Facility			
Short Causeway/Lightering	Wildlife Krusenstern Impact	Marine Biology Regional Use	Water Quality Fish Technical Feasibility Economic Feasibility
Short Causeway/Offshore Island	Marine Biology Regional Use Economic Feasibility	Water Quality Fish Wildlife Krusenstern Impact	Technical Feasibility

[1] Excludes components for which only one option remained.

[2] Disciplines having the same level of potential impact for all options of a component are not shown.

[3] Suboptions compared only with the other(s) for same corridor (i.e., GCO and Asikpak routes for northern corridor; western, Omikviorok and Kruz routes for southern corridor).

[4] Options compared only with other one for same corridor (i.e., Singoalik and Tugak Lagoon for northern corridor; VABM 17 and VABM 28 for southern corridor).

Table III-8

OVERALL RELATIVE LEVELS OF POTENTIAL IMPACT[1]

Component - Option	Overall Relative Level of Potential Impact		
	Low	Moderate	High
Tailings Pond Location	South Fork Red Dog Creek		North Fork Red Dog Creek
Water Supply	Bons Creek	Buddy Creek	
Transportation			
° Corridor Location			
- Northern		Asikpak Route	GCO Route
- Southern	Kruz Route	Omikviorok Route	Western Route
° System		Railroad Year-round Road	
Port Site			
° Location			
- Northern Corridor		Tugak Lagoon Singoalik Lagoon	
- Southern Corridor	VABM 28		VABM 17
° Transfer Facility		Short Causeway/ Lightering Short Causeway/ Offshore Island	

---

[1] Excludes components for which only one option remained.

Selection of the best northern corridor route and port site was not as clear cut. Because the northern corridor routes went to separate port sites (Fig. III-2), each route and its port site had to be considered in combination for comparison with the other. As shown in Table III-8, both the Singoalik Lagoon and Tugak Lagoon port sites were considered to have moderate levels of potential impact.

Comparison of the GCO and Asikpak routes (Table III-8) showed an overall high level of potential impact for the GCO route and an overall moderate level of potential impact for the Asikpak route. For those disciplines in which a reasonable difference existed between the two routes (Table III-7), the Asikpak route had lower relative levels of potential impact for technical feasibility, cultural resources and regional use, while the GCO route had a lower relative level of potential impact for subsistence.

Thus, while comparison of the Asikpak route/Tugak Lagoon combination with the GCO route/Singoalik Lagoon combination did not show great differences between them, on balance the Asikpak route/Tugak Lagoon combination had an overall lower potential for impacts, and it was selected as the best combination for the northern corridor.

For the two remaining components selection of the best option was not as simple. For the transportation system, the railroad initially appeared to have a lower overall level of potential impact. However, analysis showed that several of the individual discipline differences were either not significantly different, or could be mitigated or eliminated by construction or operational procedures. The road was finally selected on the bases of greater regional use flexibility, substantially less capital cost, and the fact that the transportation corridors would be initially laid out to meet the more restrictive railroad grade constraints, thus keeping open the option for construction of a railroad within the same right-of-way at a later time.

For the marine transfer facility both the short causeway/lightering and short causeway/offshore island options appeared to have about the same overall level of potential impact. An analysis of the 12 issues showed that where one option addressed some of the issues more favorably, the second addressed other issues more favorably. Thus, both options were retained for this component.

At the completion of the options screening process, therefore, the options that were retained and used to form the alternatives were those shown in Table III-9.

Transportation Corridor Identification

This section describes in more specific detail the process by which the two transportation corridor options (Asikpak route for the northern corridor and Kruz route for the southern corridor) were identified for inclusion in the alternatives. This description is included because of the importance of the location of the southern corridor which passes through Cape Krusenstern National Monument, and because of a previous attempt to identify a transportation corridor which would avoid the Monument.

Table III-9

OPTIONS USED TO FORM ALTERNATIVES

Component	Option(s)	Suboption
Mine Location	Fixed	
Tailings Pond Location	South Fork Red Dog Creek	
Mill Site Location	South Fork Red Dog Creek	
Worker Housing		
Type	Campsite	
Location	South Fork Red Dog Creek	
Water Supply	Bons Creek	
Power Generation	Diesel	
Transportation		
Corridor Location	Northern	Asikpak Route
	Southern	Kruz Route
System	Road	Year-round
Port Site		
Location	Tugak Lagoon	
	VABM 28	
Transfer Facility	Short Causeway/Lightering	
	Short Causeway/Offshore Island	

During its ANILCA deliberations, Congress decided to exclude fom National Interest Lands status certain lands within a north/south corridor in the Noatak Valley, located between the Noatak Preserve on the east and Cape Krusenstern National Monument on the west. This corridor was proposed for transportation purposes for the Red Dog prospect as well as for other potential resource developments in the Western Brooks Range and the National Petroleum Reserve. Thus, the possibility that the Red Dog project southern transportation corridor would now traverse the Monument has raised concern.

Noatak Corridor and Port Site

The scoping process initially identified three corridors, the northern, the southern and the Noatak (Table III-1). The Noatak route followed the ANILCA north/south corridor to the village of Noatak, or to an unidentified port somewhere on Hotham Inlet or Kotzebue Sound (Fig. III-2). This corridor and port option was eliminated during the initial options review because of significant potential problems with both the route and the port (Table III-3). The corridor would cross many lowlands with substantial permafrost and wetlands problems, and the many stream crossings would have impacts upon water quality and fish. If the terminus of the overland corridor was at the Noatak River, the limited barging season would require significant dredging of the Noatak River, and substantial weather and low water problems would still exist. Whether the overland corridor ended at the Noatak River or continued directly to some point on Hotham Inlet or Kotzebue Sound, either a barge to bulk carrier or port transfer facility would still have to be constructed.

Of the remaining two transportation corridor options, the southern corridor would cross the Monument while the northern corridor would completely avoid the Monument. Because of the Title XI requirement that alternate routes not crossing the Monument be fully considered in the EIS, a decision was made that a northern corridor route would be retained and incorporated in an alternative. This was done to ensure that full consideration and opportunity for formal public review would be given to a non-Monument corridor by inclusion in the draft EIS. Thus, during the analysis of the suboptions for both corridors, each corridor's routes were compared only among themselves (i.e., the GCO route and the Asikpak route were compared only against each other for the northern corridor, and the Western, Omikviorok and Kruz routes were compared only among themselves for the southern corridor). This guaranteed that a non-Monument corridor would be included in an alternative, and that the environmentally and technically best routes for each of the northern and southern corridors would be considered in the comparison of alternatives process.

Northern Corridor and Port Site

The results of the remaining options evaluation process for the northern corridor routes, when the individual discipline screening criteria were applied to both the GCO and Asikpak routes, are shown in Table III-6C, and are summarized in Table III-7. For those disciplines in which reasonable difference existed between the two routes, the Asikpak route had lower relative levels of potential impact for technical feasibility, cultural resources and regional use, while the GCO route had a lower relative level of potential impact for subsistence.

For those disciplines in which a reasonable difference existed between the two northern corridor port sites, the remaining options evaluation process (Tables III-6F and III-7) showed that Tugak Lagoon had lower relative levels of potential impact for fish and marine biology, while Singoalik Lagoon had lower relative levels of potential impact for wildlife and subsistence.

Because the northern corridor routes went to separate port sites (Fig. III-2), each route and its port site had to be considered in combination for comparison with the other. Such a comparison of the Asikpak route/Tugak Lagoon combination with the GCO route/Singoalik Lagoon combination did not show great differences between them. However, on balance, the Asikpak route/Tugak Lagoon combination had an overall lower potential for impacts, and it was tentatively selected as the best combination for the northern corridor.

The GCO route/Singoalik Lagoon combination was then reviewed against the 12 issues to see if it addressed one or more of the issues in a significantly more favorable manner than did the Asikpak route/Tugak Lagoon combination. As it did not, the Asikpak route/Tugak Lagoon combination was selected as the best one for the northern transportation corridor.

Southern Corridor and Port Site

The results of the remaining options evaluation process for the three southern corridor routes are shown in Tables III-6D and III-7, with the overall relative levels of potential impact shown in Table III-8. These tables show the specific discipline by discipline analysis of impacts which resulted in overall relative levels of potential impact of high for the Western route, moderate for the Omikviorok route, and low for the Kruz route. Although Table III-7 shows that the grouped levels of potential impact did not differ greatly between the Western and Omikviorok routes, the grouped levels of potential impact for the Kruz route were clearly lower than the other two.

For the VABM 17 and VABM 28 port sites, the results of the remaining options evaluation process are shown in Tables III-6G and III-7, with the overall relative levels of potential impact shown in Table III-8. As Table III-7 shows, the grouped levels of potential impact for the VABM 28 port site were significantly lower than those for the VABM 17 port site.

Two of the southern corridor options, the Western and Omikviorok routes, could have used either VABM 17 or VABM 28 as a port site, while the Kruz route could only use VABM 28 (Fig. III-2). To reduce the number of combinations of routes and port sites to be compared, it was decided that since the VABM 28 port site clearly had the lowest overall relative level of potential impact (Table III-8), and since it was also common to all three routes, it would be considered as the port site for comparison of all three southern corridor routes.

With VABM 28 as the common port site, selection of the best southern corridor route was straightforward (Tables III-7 and III-8). As discussed above, the Kruz route clearly had the lowest overall relative level of potential impact, and it was thus tentatively selected as the best southern corridor route.

The Western and Omikviorok routes to VABM 28 were then reviewed against the 12 issues to see if either addressed one or more of the 12 issues in a significantly more favorable manner than did the Kruz route. This review showed that both the Western and Omikviorok routes would have less impact upon the Monument by being closer to its northwest boundary than the Kruz route, with the Western route having the least impact. Even that route, however, would traverse 27.2 km (17 mi) of the Monument.

While the lesser potential for impacts to the Monument from either the Western or the Omikviorok routes was important, it was not considered to be significantly so (as would a route along the northern corridor which would completely avoid the Monument). Therefore, when the advantages of the smaller potential for impacts to the Monument from either the Western or Omikviorok routes were weighed against the significantly lower overall relative level of potential impact for the Kruz route (Tables III-7 and III-8), the Kruz route to VABM 28 was selected as the best route for the southern corridor.

As a result of the analyses described above, two transportation options remained; the Asikpak route to Tugak Lagoon for the northern corridor, and the Kruz route to VABM 28 for the southern corridor. These two options were then incorporated into the alternatives as described in the next section (Identification and Description of Alternatives). Once incorporated into the alternatives, selection of the final transportation corridor became part of the overall process for selecting the preferred alternative. This was decided by comparison of alternatives as described later in this chapter.

IDENTIFICATION AND DESCRIPTION OF ALTERNATIVES

The options screening process left only three components with more than one option remaining. These were the transportation corridor and port site locations, which were dependent upon one another, and the transfer facility. The identification of alternatives process was therefore relatively straightforward as there were only three combinations (and hence alternatives) necessary to address the issues raised by those three components with more than one option remaining (Fig. III-3).

Alternative 1

This alternative would site the tailings pond in the South Fork of Red Dog Creek with the mill in close proximity to the west (Fig. II-3). A worker camp would be located close to the mill. Power would be supplied by diesel generators also sited near the mill. Water would come from an impoundment on Bons Creek to the south of the tailings pond and airstrip. All these facilities, as well as the mine, would be located on private land owned by NANA.

Transportation would be by year-round road along the southern corridor to a port site at VABM 28 (Fig. II-6). The transfer facility would be the short causeway/offshore island (Fig. II-8).

Alternative 2

This alternative is the same as Alternative 1 for all components except the transportation corridor and port site locations (Fig. III-3). It includes the northern corridor to Tugak Lagoon (Fig. II-6). A northern corridor and

RED DOG PROJECT EIS ALTERNATIVES

ALTERNATIVES	PROJECT COMPONENTS	MINE LOCATION	TAILINGS POND	MILL SITE	WORKER HOUSING		WATER SUPPLY	POWER GENERATION	TRANSPORTATION			PORT SITE LOCATION		TRANSFER FACILITY	
					TYPE	LOCATION			CORRIDOR LOCATION		SYSTEM				
	COMPONENT OPTIONS OPTIONS VARYING AMONG ALTERNATIVES	FIXED	So. FORK RED DOG CK.	So. FORK RED DOG CK.	CAMPSITE	So. FORK RED DOG CK.	BONS CREEK	DIESEL	NORTHERN CORRIDOR	SOUTHERN CORRIDOR	YEAR-ROUND ROAD	VABM 28	TUGAK LAGOON	OFFSHORE ISLAND	LIGHTERING
1	• SOUTHERN CORRIDOR • VABM 28 PORT SITE • OFFSHORE ISLAND FACILITY	■	■	■	■	■	■	■		■	■	■		■	
2	• NORTHERN CORRIDOR • TUGAK LAGOON PORT SITE • OFFSHORE ISLAND FACILITY	■	■	■	■	■	■	■	■		■		■	■	
3	• SOUTHERN CORRIDOR • VABM 28 PORT SITE • LIGHTERING FACILITY	■	■	■	■	■	■	■		■	■	■			■
	NO ACTION														

FIGURE III-3 RED DOG PROJECT ALTERNATIVES

port site were included in an alternative to specifically address Issue Number 10 - Impacts on Cape Krusenstern National Monument. Since Alternative 1 identified a southern corridor that crossed the Monument, the question of gaining legal access through the Monument arose. The process for acquiring such access was established by Title XI of ANILCA, and requires that alternative routes be considered that would not cross the Monument. Thus, although the northern corridor and Tugak Lagoon options might otherwise have been eliminated earlier in the option screening process, both were specifically retained and included in a separate alternative to ensure this Title XI issue would be addressed during the formal draft EIS review.

Alternative 3

This alternative is the same as Alternative 1 except that the transfer facility is the short causeway/lightering option instead of the short causeway/offshore island option (Fig. II-7).

No Action Alternative

The No Action Alternative is defined as meaning no development of the Red Dog Project would occur. This alternative may be used as a baseline to which the other alternatives can be compared.

The No Action Alternative would result from denial of at least one, or perhaps more, of the federal or state permits necessary for project development. Or, it could mean that the project sponsor chose not to undertake the project. However, under both federal and state law, a landowner or leasee generally has a right to reasonable access across public lands to his land, and a right to develop that land in a manner consistent with applicable law. The specific purpose of Section 1418 of ANILCA was to permit NANA to select a known, valuable mineral prospect with the intention of developing it for the benefit of its shareholders and other residents of northwest Alaska. Therefore, it is understood that implementation of the No Action Alternative might be in conflict with existing federal and state law. However, federal regulations governing the content of EIS's require an analysis of the No Action Alternative.

COMPARISON OF ALTERNATIVES

To compare the three action alternatives it was necessary to develop evaluation criteria. Development of these criteria was based upon the twelve issues identified during the scoping process (Chapter VII) and described in Chapter I. Each of the twelve issues was considered appropriate as a criterion for evaluation of the three action alternatives. The twelve evaluation criteria are shown in the first column of Table III-10.

To evaluate the alternatives, the evaluation criteria were applied separately to each of the three alternatives to determine a relative value for the total potential impacts for each alternative. It is important to note that the "relative total impact value" assigned to a given alternative was derived only by evaluation of that alternative relative to the other two alternatives for each

Table III-10

EVALUATION CRITERIA MATRIX SHOWING RELATIVE TOTAL IMPACT VALUES ASSIGNED TO THE THREE ACTION ALTERNATIVES[1]

Evaluation Criteria	ALTERNATIVE 1 Southern Corridor VABM 28 Port Site Offshore Island Fac.	ALTERNATIVE 2 Northern Corridor Tugak Lagoon P. S. Offshore Island Fac.	ALTERNATIVE 3 Southern Corridor VABM 28 Port Site Lightering Facility
1. Minimize Risk of Water Quality Degradation	Low Risk	High Risk	Moderate Risk
2. Minimize Impacts to Fish and Fish Habitat	Low Impact	High Impact	Moderate Impact
3. Minimize Impacts to Wildlife and Wildlife Habitat	Low Impact	High Impact	Low Impact
4. Minimize Impacts to Coastal Geologic Processes	Low Impact	Low Impact	Low Impact
5. Minimize Impacts to Marine Life and Marine Habitat	Low Impact	Low Impact	Moderate Impact
6. Minimize Impacts to Traditional Subsistence Harvest Activities	Low Impact	High Impact	Moderate Impact
7. Minimize Impacts to Cultural Resources	Low Impact	Low Impact	Low Impact
8. Minimize Social, Cultural and Economic Impacts upon Residents of the Region	These impacts would be similar for all three alternatives.		
9. Maximize the Potential for Other Regional Uses	High Potential	High Potential	Moderate Potential
10. Minimize Impacts on Cape Krusenstern National Monument	High Impact	Low Impact	Moderate Impact
11. Minimize Technical Complexity	Moderate Complexity	High Complexity	Moderate Complexity
12. Minimize Costs	Low Cost	High Cost	Moderate Cost

---

[1] See text explanation on preceding page.

criterion. The relative values used were low, moderate and high. For example, using the first evaluation criterion, "Minimizing the risk of water quality degradation", each alternative was analyzed from the standpoint of its total potential risk of impact to water quality, and a relative total impact value (compared to the other two alternatives) was assigned. For this example, as shown in Table III-10, Alternative 1 had a relatively low value for total potential water quality impacts compared to Alternatives 2 and 3, which had relative values of high and moderate, respectively. Table III-10 is important as it summarizes, for each evaluation criterion and alternative, the relative total impact values for all the disciplines. Thus, the evaluation criteria and relative total impact values are devices which provide for consistent comparison of alternatives.

It must be emphasized again that while a particular alternative might be assigned a high relative total impact value when compared with the other two alternatives, that did not necessarily mean that alternative would have a high absolute impact; only that it was relatively higher than the other two alternatives. For example, Alternative 1 was assigned a high relative total impact value for impacts upon Cape Krusenstern National Monument simply because of the visual impact of the ballasted tanker. But, although this meant Alternative 1 would have a higher relative impact than the other two alternatives, the absolute impact of that visual effect was not considered significant. In this chapter, therefore, alternatives were assigned total impact values relative to one another, while the actual significance of an alternative's impacts was described under Environmental Consequences (Chapter V).

Following is a discussion, on an individual evaluation criterion basis, which describes the reasoning behind the assignment of relative total impact values to the three action alternatives. In most cases the discussion focuses on the three components which differ among the alternatives, that is: the road corridor location (southern versus northern); the port site location (VABM 28 versus Tugak Lagoon); and the transfer facility (short causeway/lightering versus short causeway/offshore island). If one of these components is not mentioned for a particular evaluation criterion, it is because there were no significant differences among the alternatives. This discussion also considers the mitigation, monitoring and reclamation measures described under Environmental Consequences (Chapter V).

Water Quality

Potential water quality impacts were evaluated primarily on the bases of the number, size and difficulty of stream crossings as they would relate to sedimentation and spill risks (for the northern and southern road corridors); and on the number of concentrate and fuel transfers as they would relate to spill risk (for the lightering and offshore island transfer facilities).

Because the northern road corridor in Alternative 2 would have six major multi-span bridges compared to one on the southern corridor in Alternatives 1 and 3, there would be a much greater opportunity for increased sedimentation and spills. For the transfer facilities, the greater number of transfers required in Alternative 3 between unstable (i.e. floating) platforms, and the necessity for the lighters to work in more marginal weather to load moored ships, were considered to have a higher risk for potential spillage than would operations at the offshore island facility in Alternatives 1 and 2.

Of the two higher potential risks, i.e. the northern corridor stream crossings and the lightering transfer facility, the environmental risks associated with the many stream crossings were considered greater. A spill or serious sedimentation problem in the ocean would much more likely be dispersed quickly over a much larger area; such a serious problem on a major stream could have impacts of far greater environmental magnitude, particularly if it occurred during the low flow period in winter or during a major fish use period.

Thus, Alternative 1 (with the southern corridor and the offshore island transfer facility) was assigned a low relative total impact value for water quality. Alternative 3, similar to Alternative 1 but with the lightering transfer facility, was assigned a moderate relative total impact value. Alternative 2, with the northern corridor, was assigned a high relative total impact value.

Fish

Potential impacts to fish and fish habitat were evaluated primarily on the bases of the number of stream crossings and possible borrow site locations at or near important spawning, rearing, overwintering or fish migration areas (for the road corridors), and on the number of concentrate and fuel transfers as they would relate to spill risk (for the transfer facilities).

The northern road corridor in Alternative 2, with 12 crossings of streams important to fish compared to 11 on the southern corridor in Alternatives 1 and 3, was considered to have significantly higher risks for potential sedimentation impacts on spawning areas, blockage of fish movements, and concentrate, fuel and reagent spills. For the marine transfer facilities, the greater number of transfers required between unstable platforms and the necessity for the lighters to work in more marginal weather to load moored ships in Alternative 3 were considered to have a higher risk for potential spillage and subsequent effects upon fish than would offshore island operations.

Of the two major potential risks, i.e., the northern corridor crossings of important fish streams and the lightering transfer facility, the risks to fish and fish habitat associated with the many fish stream crossings were considered greater. A serious sedimentation problem or major spill in the ocean would be more likely dispersed quickly over a much larger area, while such a serious problem on a major fish stream could have impacts of far greater magnitude on fish, particularly if it occurred during the low flow period in winter when fish would be restricted to relatively few deep holes under the ice.

Thus, Alternative 1 with the southern road corridor and the offshore island transfer facility was assigned a low relative total impact value for fish. Alternative 3, similar to Alternative 1 but with the lightering transfer facility, was assigned a moderate relative total impact value. And Alternative 2, with the northern route corridor, was assigned a high relative total impact value.

Wildlife

Potential impacts upon wildlife were evaluated primarily on the bases of indirect habitat loss due to noise, other disturbance or human contacts, and effects on animal movements for the road corridors, port site locations and the transfer facilities.

The northern road corridor in Alternative 2, which crosses directly through the currently used primary caribou winter range in the Wulik and Kivalina drainages, was considered to pose a higher risk of indirect habitat loss than would the southern corridor road in Alternatives 1 and 3, which would be within, but near the eastern edge of that currently used winter range. Also, the northern corridor would be more likely to affect the major spring, post-calving and fall caribou migrations than would the southern corridor.

For the port site, the Tugak Lagoon location in Alternative 2 would likely affect movements of bears and muskoxen to a greater extent than would the VABM 28 location in Alternatives 1 and 3 because it would be located in a much narrower and more restricted area between the coast and the first hills.

For the transfer facility, the offshore island in Alternatives 1 and 2 would likely have marginally greater indirect habitat loss and migration effects upon marine mammals than the lightering facility in Alternative 3.

Of the three higher potential risks, i.e., the northern corridor caribou winter range and movement impacts, the Tugak Lagoon bear and muskoxen movement impacts, and the offshore island effects upon marine mammals, the first two are found in Alternative 2 while the third is common to Alternatives 1 and 2. The combined potential risks to wildlife associated with the northern corridor and Tugak Lagoon port site locations were considered to be significantly greater than those associated with the southern corridor and offshore island. Thus, Alternatives 1 and 3 were assigned low relative total impact values for wildlife while Alternative 2 was assigned a high relative total impact value.

Coastal Geologic Processes

Potential coastal geologic processes impacts were evaluated on the bases of net sediment transport, facility erosion and lagoon breaching for the port site locations and the transfer facilities.

For both the VABM 28 port site in Alternatives 1 and 3 and the Tugak Lagoon port site in Alternative 2, the potential effects on sediment transport and erosion were considered similar. Lagoon breaching would take place at either port site and the effects were considered similar.

For the transfer facility, it was considered that the presence of the ballasted tanker in Alternatives 1 and 2, or its absence in Alternative 3, would be insignificant to net sediment transport, erosion or lagoon breaching at either of the port sites.

For the port site locations and the transfer facilities, therefore, no major difference existed between the three alternatives. All were considered to have a low relative total impact for coastal geologic processes.

Marine Biology

Potential marine biology impacts were evaluated primarily on the bases of the quality and quantity of benthic habitat disturbed, disruption of sedimentation and organism movement patterns, lagoon breaching and spill hazards for both the port site location and transfer facility.

Differences among the three alternatives were considered to be negligible with respect to disruption of sedimentation and organism movement patterns. The VABM 28 port site location in Alternatives 1 and 3 was considered to have a lesser density and diversity of benthic organisms than the Tugak Lagoon port site. The offshore island transfer facility in Alternatives 1 and 2 was considered to have a greater net loss of benthic habitat (due to the ballasted ship) than the lightering facility in Alternative 3. However, the offshore island facility was considered to have a lower risk for concentrate and fuel spills than the lightering facility.

The differences in potential impacts between port site locations were not considered significant. For the transfer facility, the greater loss of benthic habitat from the offshore island in Alternatives 1 and 2 was considered insignificant compared to the greater risk of spills from the lightering facility. Thus, both Alternatives 1 and 2, with the offshore island transfer facility, were assigned a low relative total impact value for marine biology while Alternative 3, with the lightering transfer facility, was assigned a moderate relative total impact value.

Subsistence

Potential subsistence impacts were evaluated primarily on the bases of interference with traditional harvest activities and increased nonresident harvest of fish and wildlife resources for the road corridors, port sites and transfer facilities.

The southern road corridor in Alternatives 1 and 3 was considered to have a much lower risk of interference with traditional harvest activities; it would parallel the primary winter caribou range in the Kivalina and Wulik drainages rather than cut across it as would the northern corridor in Alternative 2. Also, the southern corridor would cross fewer fish streams important for subsistence use than would the northern corridor. The southern corridor would also provide less access to prime subsistence harvest areas for nonresidents who might compete with local residents for the same fish and wildlife resources.

The VABM 28 port site in Alternatives 1 and 3 would likely have a marginally greater impact upon marine mammal hunting than the Tugak Lagoon port site in Alternative 2.

The offshore island transfer facility in Alternatives 1 and 2 was considered to have a lower risk of concentrate and fuel spills than the lightering facility in Alternative 3, although the offshore island might cause some additional sound or activity disturbance during the spring marine mammal subsistence hunting period.

While the difference between the VABM 28 port site in Alternatives 1 and 3 and the Tugak Lagoon site in Alternative 2 was considered insignificant, the risk of potential impacts to subsistence harvests by the northern road corridor in Alternative 2 compared to the southern road corridor in Alternatives 1 and 3 was considered significant. And, for the transfer facility, the lightering facility in Alternative 3 was considered to have the greater risk of potential impact because of the higher spill hazard compared to the offshore island in Alternatives 1 and 2.

Thus, Alternative 1, with the southern corridor and offshore island facility, was assigned a low relative total impact value for subsistence. Alternative 2, with the northern corridor and the offshore island transfer facility, was assigned a high relative total impact value. Alternative 3, with the southern corridor and lightering facility, was assigned a moderate value.

Cultural Resources

Potential cultural resources impacts were calculated primarily on the bases of the number of sites which would likely be impacted and whether they are within Cape Krusenstern National Monument or the Cape Krusenstern Archeological District; whether primary impacts could be avoided by reasonable corridor, port site or transfer facility relocation; and whether protective measures could be taken to avoid secondary impacts.

All sites would be avoided if reasonably possible during road and port facilities design and construction; SHPO- and ACHP-approved recovery operations would be used to preserve site data and material that could not be reasonably preserved in place; and approved measures would be used to protect sites near the corridor and port facilities from secondary impacts.

The southern road corridor in Alternatives 1 and 3 includes 13 cultural sites, seven of which are within the Cape Krusenstern Archeological District (six of these being within the Cape Krusenstern National Monument). There are 23 cultural sites within the northern road corridor identified by reconnaissance survey. Sites along the northern corridor road have not been evaluated against National Register of Historic Places Criteria for Evaluation (36 CFR 60.4).

The VABM 28 port site in Alternatives 1 and 3 contains a historical site that appears to meet National Register criteria, while the Tugak Lagoon port site in Alternative 2 has only a small eroding sod cabin that might meet National Register of Historic Places criteria for eligibility.

The offshore island and lightering transfer facilities for all three alternatives would have no impacts on known cultural resources.

No significant difference in potential impacts was determined among the three alternatives and they were each assigned a low relative total impact value.

Social, Cultural and Economic Impacts

Potential social, cultural and economic impacts of the Red Dog project would occur largely from development of the project as a whole and would not depend on selection of any particular alternative. Such impacts would therefore not be significantly altered by selection of any one of the three action alternatives and are not discussed further here. The social, cultural and economic impacts of the project are discussed in Chapter V.

Regional Use

Potential impacts to regional use by development of the road corridors, port sites and the transfer facilities were evaluated primarily on the bases of their size and location, adaptability for other potential users, and whether any other uses would be precluded. As described under Regional Use in Chapter V, a guarantee of reasonable access and use by other industrial resource users was considered assured for the following analysis.

The offshore island transfer facility in Alternatives 1 and 2 was considered to be more flexible for other users than the lightering facility in Alternative 3. The size and location of the port site and transfer facilities in all three alternatives were considered to be adequate for any needed expansion. No preclusion of any other uses was identified for any of the alternatives.

Since this would be the first major development in this area of Alaska, it is not possible to accurately assess the best route location from the standpoint of other potential users. GCO's Lik prospect, which would likely be one of the earlier users of any transportation system developed for the Red Dog project, would be closer to the northern corridor. However, this route would be correspondingly further from Red Dog which is now actively being developed. The Lik prospect would be reasonably accessible from either corridor location.

In assigning relative total impact values, Alternatives 1 and 2 with the offshore island facility were assigned high values for regional use potential, while Alternative 3 with the lightering facility was assigned a moderate value for regional use potential.

Cape Krusenstern National Monument

Potential impacts on Cape Krusenstern National Monument were evaluated among the alternatives primarily on the bases of impacts on cultural resources, littoral sediment transport effects upon the Cape Krusenstern beach ridges, increased access to the Monument and the visual impact of the marine transfer facility. Since Alternative 2 with the northern corridor and Tugak Lagoon port site would not impact Cape Krusenstern National Monument, it was not considered further in this analysis and was assigned a low relative impact value for potential Monument impacts. Also, since potential impacts from the southern corridor road and the VABM 28 port site location would be identical for Alternatives 1 and 3, these impacts were not considered in differentiating between these alternatives. Therefore, for Alternatives 1 and 3, only the type of transfer facility differed.

Neither the offshore island nor the lightering facility was considered to have a significant potential for impact upon the Monument from the standpoint of interference with littoral sediment transport, nor would either facility significantly affect access to the Monument more than the other. The offshore island facility, however, with the large tanker ballasted on the seabed was considered to have a higher visual impact compared to the lightering facility. Thus, Alternative 1 with the offshore island facility was assigned a high relative total impact value while Alternative 3 with the lightering facility was assigned a moderate value.

Technical Complexity

Potential technical complexity impacts were evaluated primarily on the basis of the relative complexity of the design, construction and operation of the road, port site and transfer facilities.

The southern corridor road in Alternatives 1 and 3 would have one major multi-span bridge over 30.5 m (100 ft) in length and four single-span bridges under 30.5 m in length, and 19 percent of its alignment would traverse soil, slope, permafrost and other conditions in which construction would be considered moderately difficult or difficult. The northern corridor road in Alternative 2 would have six major multi-span bridges and six single-span bridges, and 41 percent of its alignment would traverse conditions in which construction would be considered moderately difficult or difficult. For these reasons, the southern corridor road was considered to have significantly less technical complexity than the northern corridor road.

The VABM 28 and Tugak Lagoon port sites both had suitable soils and both sites were considered to be of equivalent complexity.

The offshore island transfer facility in Alternatives 1 and 2, with a self-propelled lighter, more conveyors, a buried fuel pipeline and possible winter ice scour problems was considered to be of approximately equally high technical complexity to the lightering facility in Alternative 3 with tug-assisted barges, clam shovel concentrate transfers between two unstable platforms, and fuel lightering to shore.

Alternative 2, therefore, with the technically more complex northern corridor road and high complexity offshore island transfer facility was assigned a high relative total impact value for technical complexity. Alternatives 1 and 3 with the less complex southern corridor road and high complexity offshore island facility were assigned moderate relative total impact values.

Cost

The estimated capital cost for the southern road corridor in Alternatives 1 and 3 would be approximately $74.7 M (Table V-16), while the cost for the northern road corridor in Alternative 2 would be approximately $125.7 M, or a difference of $51 M. The estimated annual operating costs would be approximately $2.6 M and $3.3 M, respectively, or a difference of $0.7 M.

The estimated capital cost for the offshore island marine transfer facility in Alternatives 1 and 2 would be approximately $54.7 M, while the cost for the lightering facility in Alternative 3 would be approximately $74.0 M, or a difference of $19.3 M. The estimated annual operating costs would be approximately $1.6 M and $3.0 M, respectively, or a difference of $1.4 M. On the basis of these estimates, the lightering facility would be significantly more costly than the offshore island facility both to construct and maintain.

Alternative 1, with the southern corridor and offshore island facility, would be significantly less expensive than Alternative 2, with the northern corridor and offshore island. Costs associated with Alternative 3, with the southern corridor and lightering facility, would be intermediate between Alternatives 1 and 2.

IDENTIFICATION OF PREFERRED ALTERNATIVE

As described above, the alternative evaluation process assigned relative total impact values to each of the three action alternatives as shown in Table III-10. While the individual evaluation criteria were not weighted equally, a broad review of Table III-10 showed that, from the standpoint of best addressing the 12 evaluation criteria, Alternative 1 rated equal to or better than Alternatives 2 and 3 for nine of the 11 criteria for which comparison was possible. Alternative 2 rated equal to or better than Alternatives 1 and 3 for five of the 11 criteria, and Alternative 3 rated equal to or better than Alternatives 1 and 2 for three of the 11 criteria.

On a more specific basis, the alternatives were compared to each other. Because they differed only for the marine transfer facility, Alternatives 1 and 3 were compared first. Alternative 1 showed a greater potential impact for only one of the evaluation criteria, while Alternative 3 showed greater potential impacts for six of the criteria. Alternative 1 showed greater potential impacts to Cape Krusenstern National Monument based upon the visual impact of the ballasted tanker at the VABM 28 port site.

Conversely, Alternative 3 showed greater potential for impacts on water quality, fish, marine life, subsistence, regional use and cost. The first four were based upon similar and important concerns for the increased risks associated with the lightering facility. The lesser flexibility of the Alternative 3 lightering facility for regional use was not considered a significant difference. For the sixth criterion, cost, Alternative 3 was significantly greater.

In comparing Alternatives 1 and 3, therefore, the major differences were that Alternative 1 would have a higher visual impact upon the Monument, while Alternative 3 would have higher potential for impacts to water quality, fish, marine life and subsistence from higher spill risks, and significantly greater costs.

Alternative 1 was then compared to Alternative 2. Alternative 1 showed a greater potential impact for only one of the evaluation criteria, while Alternative 2 showed greater potential impacts for six of the criteria. Alternative 1 showed a clear, and substantial, greater potential impact to Cape Krusenstern National Monument since Alternative 2 would have virtually no direct impact upon the Monument.

Conversely, Alternative 2 showed greater potential impacts for water quality, fish, wildlife, subsistence, technical complexity and cost. While the technical complexity criterion could be considered as a relatively insignificant difference between the two alternatives, the other five were considered significant.

In comparing Alternatives 1 and 2, therefore, the major differences were that Alternative 1 would have a substantially higher potential impact upon the Monument, while Alternative 2 would have higher potential for impacts to water quality, fish, wildlife, and subsistence, and significantly greater costs.

Thus, in comparison among the alternatives, Alternative 1 showed substantially fewer potential impacts for the evaluation criteria. However, Alternative 1 showed higher potential impacts to the Monument, substantially so when compared to Alternative 2.

Alternative 1 has been identified by the co-lead agencies as the preferred alternative.

IV. AFFECTED ENVIRONMENT

INTRODUCTION

This chapter describes the existing environment without the project, emphasizing those environmental aspects of the Red Dog project area* that may be affected by the construction and operation of the proposed mining facility. Baseline environmental investigations were initiated in the early summer of 1981, and data collection has continued through the summer of 1983. Environmental field studies, literature surveys and mapping have been documented. Much of this information is included as appendices to this document, or is on file at those sites identified in the Summary Sheet.

HISTORY

Traditionally much of northwest Alaska is used extensively by residents for their subsistence livelihoods. Following the purchase of Alaska from Russia in 1867, the aboriginal land claims of Alaska Natives, including northwest Natives, were formally recognized. As early as the federal Organic Act of 1884 it was stated (in Section 8) that:

> ...The Indians or other persons in said district shall not be disturbed in the possession of any lands actually in their use or occupation or now claimed by them but the terms under which such persons may acquire title to such lands is reserved for future legislation by Congress...

The current status of lands in northwest Alaska bears the imprint of three major federal land laws: the Alaska Statehood Act of 1958, the Alaska Native Claims Settlement Act of 1971 (ANCSA) and the Alaska National Interest Lands Conservation Act of 1980 (ANILCA). As these laws are still in the process of being implemented, land ownership and management status are only partly settled; much remains to be resolved as implementation continues.

Pending resolution of the Native land claims question, virtually all land in the region remained in the federal public domain, managed by the federal Bureau of Land Management (BLM), until the Alaska Statehood Act authorized the State of Alaska to select federal lands as part of its statehood entitlement. However, the land claims of Alaska Natives remained unresolved until ANCSA's passage in 1971.

---

* Defined in Glossary.

ANCSA set out terms for resolving Native land claims as part of the complex package of land legislation that also addressed ownership and management of state and federal lands in Alaska. In simplest terms, ANCSA appropriated funds and land entitlements to compensate Alaska Natives in exchange for extinguishment of their unresolved aboriginal land claims. These benefits were distributed through and administered by a two-tiered structure of private village and regional corporations established pursuant to ANCSA. Based on population, traditional Native villages received a share of funds and selection rights to the surface estate of lands at or near their traditional settlement sites. Similarly, regional corporations received funds and full fee land selection rights, plus subsurface estate rights to village land selections within their regions.

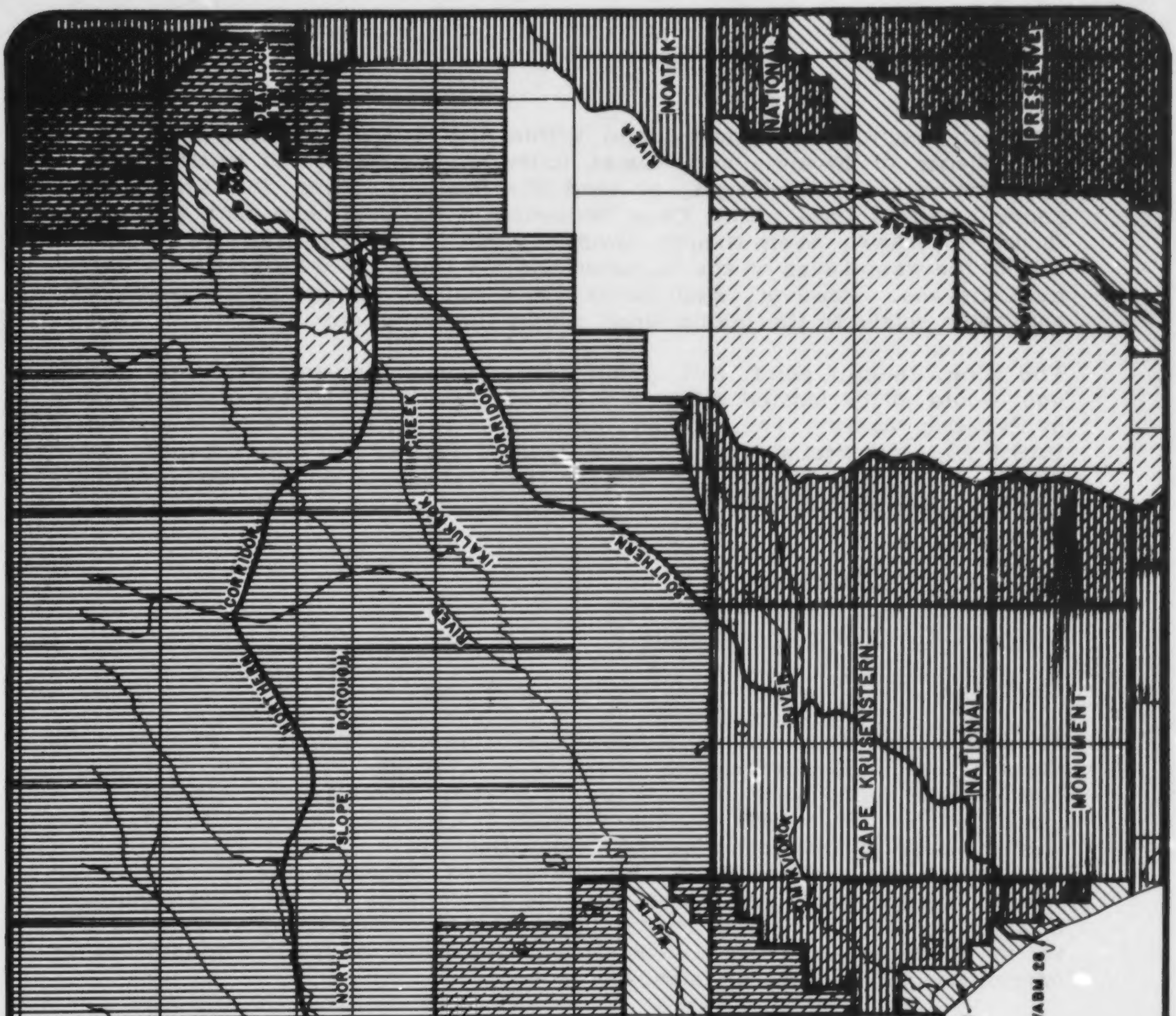
The NANA Regional Corporation for northwest Alaska is one of 12 in-state regional corporations established under ANCSA. Originally, there were also 11 village corporations set up in the region. Both the NANA Regional Corporation and the village corporations of Kivalina and Noatak had land selection rights within the Red Dog project area. Subsequently, all of the NANA region's village corporations except Kotzebue merged with the regional corporation, pooling land assets and land management functions.

ANILCA amended some terms of ANCSA, including giving NANA the right to select the Red Dog prospect. Also of significant importance to the project, ANILCA established the Cape Krusenstern National Monument under management of the National Park Service to, among other purposes, protect and interpret the archeologic sites and other evidence of prehistoric and historic Native cultures, and to protect the viability and use of subsistence resources.

LAND STATUS

The Red Dog project area (Figure III-2), encompassing the mine, mill, housing and tailings pond sites, and the transportation corridor and port site options, falls within the northwestern corner of the NANA Regional Corporation's boundaries. Overall, the project area includes only a small portion (about 650,000 ha [1.6 million ac] or less than five percent) of the land and waters encompassed by the NANA region. Nearly all of the project area is within the so-called unorganized borough. That is, it is outside any incorporated city or borough governmental jurisdiction. Only the mine site and a thin strip immediately to the south fall within the North Slope Borough.

Recognizing that land status within the project study area is fluid pending exercise of outstanding selection rights and resolution of overlapping Native and state selections, current land ownership and management status of the project study area's 650,000 ha (1.6 million ac) can be summarized very approximately as follows (Fig. IV-1): State of Alaska selected, tentatively approved or patented lands, some of which are overlapped by and may be superceded by Native selections, comprise about 50 percent; federal lands, chiefly Cape Krusenstern National Monument (about 85,000 ha [210,000 ac]) and other federal (d-l) lands (about 89,000 ha [220,000 ac]), amount to about 29 percent; Kivalina and Noatak village selections cover about 65,000 ha (160,000 ac) or 10 percent of the project area; most of the rest consists of regional corporation selections and overselections, part of which may ultimately revert to the federal or state governments.


LEGEND
STATE (SELECTED & T.A.)
NANA TITLE RECEIVED (I.C.)
SELECTED
FEDERAL CONSERVATION SYSTEM
PUBLIC DOMAIN
6 miles
9.6 Kilometers
TUGAK LAGOON
CHUKCHI SEA
KIVALINA
IPIAVIK LAGOON
VABM 28
CAPE KRUSENSTERN NATIONAL MONUMENT
NOATAK NATIONAL PRESERVE
NOATAK RIVER
SOUTHERN CORRIDOR
NORTHERN CORRIDOR
IKALUKROK CREEK
NORTH SLOPE BOROUGH
SOUTH BOUNDARY
RIVER
OMIKVIOROK RIVER
WULIK
KIVALINA RIVER

STATUS CURRENT TO 10/14/83

FIGURE IV-1 LAND STATUS IN PROJECT AREA

IV-3

Although much of the Native land within the project area was selected by the villages of Kivalina and Noatak following the merger of NANA Regional Corporation with its villages, all land title issued has been in NANA's name. Lands selected from within Cape Krusenstern National Monument and transferred to NANA, even though owned by NANA in fee title, would remain within the boundaries of the Monument unless those boundaries were changed by Congress. However, such lands would not be subject to the regulations applicable solely to the public lands within the Monument.

The mine, tailings pond, mill, power plant, worker housing and water reservoir would all be located within a 8,975 ha (22,176 ac) parcel of private land in Red Dog Valley. The port site would also be on private land if located at VABM 28, and probably on private land if located at Tugak Lagoon since NANA could still select that area. The transportation corridor would be almost totally on public land.

AFFECTED ENVIRONMENT

Geology, Physiography and Soils

Geology

The Red Dog mine site is located approximately 89 km (55 mi) from the Chukchi Sea, east-northeast of Kivalina and 132 km (82 mi) north of Kotzebue. Local topography consists of moderately sloping hills with elevations ranging from 243 to 455 m (800 to 1500 ft). The ore deposit lies at the western base of Deadlock Mountain (elevation 913 m [2,995 ft]), and is surrounded to the north and east by the rugged ridges of the De Long Mountains. To the west and southwest, the foothills of the De Long Mountains drop off to gently sloping coastal uplands. The coastal region consists of a series of closed and open coastal lagoons separated from the Chukchi Sea by narrow barrier beaches or islands.

The De Long Mountains are generally underlain by folded and faulted thrust sheets of sedimentary rocks which are intruded by mafic* and ultramafic rocks (containing large percentages of dark-colored minerals). Bedrock in these mountains consists principally of limestone, sandstone, shale, chert and mafic igneous* rocks (Selkregg, 1974).

The geology of the eastern portion of the project area, including the mine site, generally consists of bedrock deposits of Mississippian conglomerate that contain shale and limestone with subordinate shale, chert and dolomite. Bedrock igneous complexes of mafic volcanic and intrusive rocks are also present.

Coastal upland regions further west in the project area generally consist of unconsolidated deposits of glacial moraine*, as well as glaciofluvial or outwash deposits associated with glaciers or bordering older moraines. Glacial moraines are fairly regular, low, linear hills which are formed at the edge of glaciers. Moraines generally consist of a complex mixture of unsorted gravel, sand, silt and clay.

---

* Defined in Glossary.

In addition to unconsolidated deposits, the upland regions located between the Kivalina and Wulik Rivers, and between the Singoalik and Kivalina Rivers, also contain areas of bedrock outcroppings. These consist of ultramafic intrusives; igneous complexes of mafic volcanic and intrusive rocks; and Precambrian- to Devonian-aged rocks consisting of limestone, dolomite, chert and phyllite (Selkregg, 1974).

The coastal region in the project area consists of unconsolidated deposits of older, interlayered alluvium* and marine sediments. These formations were laid down in shallow, nearshore shelf environments where frequent sea level changes alternately exposed and submerged portions of the gently sloping terrain. Deposits consist of alternating lenses and mixtures of gravel, sand, silt and clay. More modern coastal beaches, spits, bars and deltas are also present in the region.

Seismology

According to Corps classification, the project area falls within Seismic* Risk Zone 2. This designation applies to areas that could be affected by earthquakes with maximum magnitudes of 4.5 to 6.0 on the Richter scale. The only seismic activity reported in northwestern Alaska between 1955 and 1964 occurred in the Chukchi Sea. It is believed that seismic shocks occur inland, but equipment is not available in the area to record such events (Selkregg, 1974).

Physiography

The project area is characterized by moderately sloping hills, broad stream valleys and coastal lowland lagoon systems. The entire area is underlain by permafrost. Gentle, poorly defined surface undulations are caused by patterned ground, old drainage channels, thaw lakes, and other depositional, erosional or permafrost related features (Fig. IV-2).

Polygonal or patterned ground is a conspicuous surface feature, especially near the coast. Temperature-induced contraction cracks are formed in polygonal patterns similar to those encountered on dry mud flats. These cracks fill with water and freeze. Continued cracking, filling and freezing along the same lines eventually form a network of ice wedges that sometimes become several meters deep and are generally spaced tens of meters apart. In time the ice wedges form troughs bounded by ice push ridges. Troughs, ridges and undisturbed central areas are referred to as ice-wedge polygons (Selkregg, 1974).

Thaw lakes are also important features in the area. These usually originate from small, shallow ponds that generally begin in low-centered polygons or at the intersection of ice wedges (Sellmann et al., 1975). Other nearby ponds expand and coalesce to form larger ponds and lakes. During the summer period, the underlying permafrost is thawed, which allows deepening

---

* Defined in Glossary.

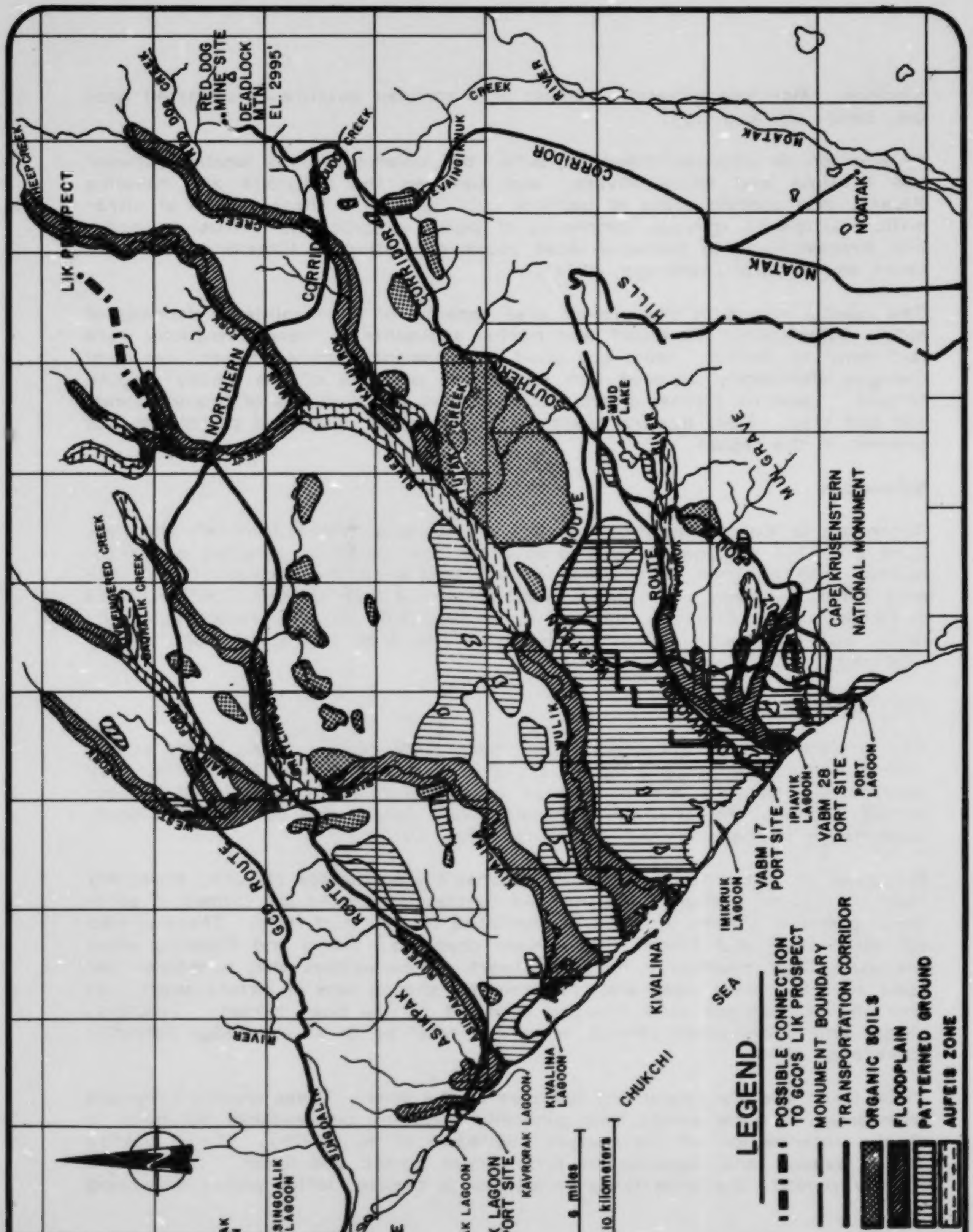

LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
ORGANIC SOILS
FLOODPLAIN
PATTERNED GROUND
AUFEIS ZONE
5 miles
10 kilometers
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
LIK PROSPECT
RED DOG CREEK
SHEEP CREEK
NORTHERN CORRIDOR
SOUTHERN ROUTE
GCO ROUTE
NOATAK
NOATAK RIVER
HILLS
MUD LAKE
MULGRAVE
CAPE KRUSENSTERN NATIONAL MONUMENT
WULIK RIVER
KIVALINA RIVER
ASIKPAK RIVER
SINGOALIK
PUSIGRAK LAGOON
SINGOALIK LAGOON
SINGOALIK LAGOON PORT SITE
TUGAK LAGOON
TUGAK LAGOON PORT SITE
KAVRORAK LAGOON
KIVALINA LAGOON
KIVALINA
CHUKCHI SEA
IMIKRUK LAGOON
VABM 17 PORT SITE
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON

FIGURE IV-2
POOR SOILS IN PROJECT AREA

IV-6

and enlarging of the small lake. As the lake expands, it joins with others and becomes deep enough to maintain a thaw bulb*. Because thaw lakes are largely unstable with active erosion at basin margins, lake basins often coalesce and drain. The thaw lake cycle consists of repetitive stages of lake formation and ultimate drainage, and is the primary geomorphic process that modifies the land surface. Nested and overlapped drained basins contribute most to characteristic topography formation, and drainage and wetland distribution.

Among other important surface features in the area are pingos. These are small, conical hills which have a central core of ice. Closed-system pingos develop when tundra thaw lakes drain and permafrost encroaches from the sides. As sediments near the center slowly freeze, massive segregation of ice develops. Volume increases as freezing occurs and pushes the tundra and ice upward, forming a large, ice-cored mound or pingo. As the pingo expands upward a summit crack or fissure often opens, exposing the ice core and allowing part of it to melt and a small lake to form in the crater. Closed-system pingos are characteristic of the continuous permafrost zone (Selkregg, 1974).

Floodplains

The floodplains of the Kivalina and Wulik Rivers consist of unconsolidated deposits of alluvial material (Fig. IV-2). Alluvial deposits represent rock materials that are picked up and carried along in streams and rivers. As materials move downstream, they are gradually broken, abraded, rounded, and eventually deposited as stream velocity decreases. Older alluvial deposits that formed in coastal plains during the Pleistocene Epoch are often interfingered with marine sediments that were deposited during that time.

Seasonal hydrologic variations, though not documented for the Wulik and Kivalina Rivers, are likely to be similar to those of the Noatak River basin as reported by Childers and Kernodle (1981). Both rivers begin to freeze over in October and exhibit annual low flows from January through April. Annual peak flows occur in May or June as a result of snowmelt during spring breakup. Both rivers exhibit rapid response to precipitation events as a result of shallow permafrost depths and correspondingly small groundwater storage capacity.

Channel geometry surveys (Childers et al., 1979) were conducted near the Wulik and Kivalina River mouths in order to determine the two-year and 50-year flood discharges. This study computed the two-year and 50-year flood flows to be 476 and 1,232 m^3/s (17,000 and 44,000 ft^3/s), respectively, for the Wulik River, and 336 and 924 m^3/s (12,000 and 33,000 ft^3/s), respectively, for the Kivalina River.

Areas of thick ice cover occur within the Wulik and Kivalina River drainages as a result of aufeis* formation (Fig. IV-2). Aufeis occurs due to confinement of surface and groundwater flows as ice and frost formations penetrate deeper through winter. If confinement pressures become sufficient, the ice cover is fractured and pressure ridges are formed as the escaping water is frozen in thin surface sheets.

---

* Defined in Glossary.

Soils

Soils vary considerably in the project area depending on location and vegetation cover. The seasonal thaw or active layer also varies throughout the area. It generally ranges from 50 to 100 cm (20 to 39 in) deep in vegetated areas and may range up to 3 m (10 ft) deep on exposed, rocky hillsides. In general, the slopes of rolling hills have mineral, silty soils with some sphagnum peat. River terraces are characterized by sandy, silty soil overlying cobbles. Upland drainage channels have sphagnum peat and mineral soil types, while moraine knolls have mineral, rocky soils. Lake basins are generally characterized by mineral, organic, silty soils (Fig. IV-2).

Permafrost

Permafrost is not a material; it is the temperature state of a material and is usually defined as any area which remains below 0°C for a period of two or more years. Rock or gravel can be permafrost, and its thawing will not usually cause settlement. However, ice can be permafrost (such as an ice lens in the ground or even a glacier) and its thawing would very much affect the surrounding environment. The temperature of soil can be well below 0°C and be officially classified as permafrost, but it may not be hard frozen and may be structurally similar to unfrozen ground. This is caused by saline pore water and is a common occurrence along the western and northern coasts of Alaska. This soil may not be hard frozen until its temperature is lowered several degrees below 0°C.

Although the entire Red Dog project area is underlain by permafrost, the vertical extent of the permafrost and its properties at depth are not well defined at this time. Permanent thaw bulbs are present under the beds of major waterways such as the Wulik and Kivalina Rivers and Ikalukrok Creek.

Mineral Resources

Weathering sulfide minerals have been reported in a 259 km² (100 mi²) area in the northwestern Brooks Range. The most significant area of mineralization within this region is the Red Dog prospect (Tailleur, 1970; Jansons and Bottge, 1977). Outcroppings containing high concentrations of lead, zinc, silver and barite are present at this mine site, and the subsurface ore body is thought to contain 77 million Mg (85 million tons) of high grade ore (17.1 percent zinc, 5.6 percent lead, 75.0 g/Mg [2.4 oz/ton] silver). There are indications that these minerals may extend at shallow depths throughout much of the northwestern Brooks Range region (WGM, Inc., 1978). Other minerals reported in the De Long Mountains region, but outside the project area include: copper, chromium, nickel and chrysotile serpentine (asbestos).

Nonmetallic mineral resources in the project area consist of deposits of sand and gravel along the Kivalina and Wulik Rivers and at the coast (Selkregg, 1974).

Vegetation and Wetlands

Using the classification system of Viereck et al. (1981), 13 vegetation types were described for the project area (Dames & Moore, 1982a). Vegetation types at the mine site, along the transportation corridors and at the alternate port sites range from xerophytic*, upland mat and cushion tundra to wet, lowland sedge-grass marsh. Vegetation consists primarily of cottongrass tussock tundra, low shrublands and herbaceous meadows, in order of relative abundance. Complexes of up to three vegetation types are also common throughout the project area (Dames & Moore, 1982a).

Vegetation Type Descriptions

Shrubland

Both closed and open tall shrub vegetation types (greater than 1.5 m [5 ft] tall) occur in the study area. Closed (more than 75 percent foliar cover) tall shrub communities occur in relatively few locations, primarily as riparian or snowbank vegetation along streams. Grayleaf willow (Salix glauca) dominates this vegetation type, which usually contains an understory of sweet coltsfoot (Petasites frigidus) and moss. Open (25 to 75 percent foliar cover) tall shrub communities are more abundant and more variable in species composition throughout the study area. Diamondleaf willow (Salix planifolia pulchra), feltleaf willow (S. alexensis), or a mixture of both occur along most stream terraces in the area, usually with an understory of bluejoint (Calamagrostis canadensis).

Low shrub vegetation (20 cm [8 in] to 1.5 m [5 ft] tall) is very abundant in the study area and includes tundra as well as closed and open low shrub types. Low shrub tundra communities are dominated by such species as four-angled cassiope (Cassiope tetragona), crowberry (Empetrum nigrum) and bog blueberry (Vaccinium uliginosum). Other woody plants such as dwarf Arctic birch (Betula nana) and willow species may be present as codominants in this community. Low shrub tundra vegetation is quite common on the upland rolling hills where it often forms a complex with cottongrass (Eriophorum spp.) tussock tundra.

Closed low shrub communities occur sporadically along the two transportation corridors, but are prevalent near the coast on slopes directly above the beach. Dominant species in this community include dwarf Arctic birch, diamondleaf willow, bog blueberry and narrow-leaf Labrador-tea (Ledum decumbens).

Open low shrub communities are common on upland rolling hills and riparian stream terraces located along the transportation corridors. This vegetation type consists primarily of a codominance of willow and assorted heath species. Dwarf Arctic birch, bog blueberry, moss and herbaceous species may also codominate this vegetation type.

Dwarf shrub mat and cushion tundra communities are primarily associated with upland ridges and bedrock outcroppings located above 244 m (800 ft) elevation in the De Long Mountains. This vegetation type typically contains white mountain-avens (Dryas octopetala) in association with a variety of willow, heath and lichen forms, depending on the moisture content of the soil. On more mesic* sites, dwarf Arctic birch and narrow-leaf Labrador-tea may also describe a community.

---

* Defined in Glossary.

Herbaceous

Herbaceous tall grass (greater than 1 m [3 ft] tall) communities occur along the coastal dune regions of the study area. This vegetation type is dominated by lyme grass (*Elymus arenarius mollis*) in association with beach pea (*Lathyrus maritimus pubescens*).

Sedge-grass tundra communities typically occur in lake basins or infilled backwater areas along streams where there is no surface water and water inundation of the soil profile may occur for only part of the growing season. This vegetation type is usually composed of various combinations of cottongrass (*Eriophorum vaginatum*, *E. angustifolium*) and the sedge *Carex aquatilis aquatilis*, although willow and moss species, may also occur.

Tussock tundra is by far the most prevalent vegetation type along the transportation corridors, typically occurring on rolling upland slopes. Cottongrass is the principal species of tussock tundra, but the community usually contains codominant species of various other sedges (*Carex bigelowii*, *C. microchaeta*), bog blueberry, narrow-leaf Labrador-tea, dwarf Arctic birch, and *Sphagnum* moss.

Sedge-grass marsh communities usually occur near lakes and in historic lake beds which contain at least 15 cm (6 in) of surface water. This vegetation type usually contains pendent grass (*Arctophilia fulva*) or sedge (*Carex aquatilis*) in association with a codominant such as mare's tail (*Hippuris vulgaris*).

Sedge-grass wet meadow communities are similar to sedge-grass marsh communities but occur in historic, infilled lake basins and high- or low-centered polygonal ground having less than 15 cm (6 in) of surface water. *Carex* species dominate this vegetation type, although common associates include cottongrass species, bog blueberry and mosses.

Sedge-grass bog meadow communities are similar to sedge-grass wet meadow communities but occur only in poorly drained lake basins which have peat soil at least 30 cm (12 in) deep. As with wet meadow communities, dominant species of this vegetation type include *Carex* species, cottongrass, bog blueberry, narrow-leaf Labrador-tea and *Sphagnum* species.

Wetland herbaceous communities occur in small ephemeral ponds located between sand dunes and along some coastal lagoons. Halophytic* (salt-adapted) herb wet meadows are dominated by arrow grass (*Triglochin maritimum*), though mare's tail may also be present. In more freshwater habitats, this vegetation type is dominated by horsetail (*Equisetum* spp.).

Wetlands

Development in wetland areas is regulated by federal law to the extent that any discharge of dredged or fill material may require a Department of the Army (DA) permit. The Corps defines wetlands as "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support . . . a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (Federal Register 47[141]:31811). Vegetation, though, is only one indication of a wetland system. Other parameters include the hydrologic regime and soil characteristics. All three parameters should be considered in determining wetlands. The identification of wetlands in Arctic areas is complicated by the fact that permafrost can impede the drainage of soils, and large areas not considered typical wetlands may become water-saturated as thawing progresses through a growing season.

---

* Defined in Glossary.

Wetlands were set aside for special consideration because they may provide valuable habitat and perform important natural functions. Therefore, a wetlands evaluation must go beyond identification and take into consideration the ecological contribution made by the defined communities. In addition to providing habitat, important functions of the wetland system of the project area include flood control, particularly in the major wetland area near Kivalina; nutrient and detrital movement, particularly in wetland areas adjacent to lagoons and other aquatic systems; filtration; erosion control and runoff retardation.

Several vegetation types identified in the project area satisfy the technical wetland criteria (i.e., plant species are either facultative or obligate hydrophytes*, soil has hydric* characteristics, and the soil is saturated or inundated during a portion of the growing season). These wetland vegetation types include sedge-grass marsh, sedge-grass wet meadow, sedge-grass bog meadow, wetland herbaceous, sedge-grass tundra, tussock tundra and open low shrub communities.

In general, riparian tall and low shrub vegetation types are classified as wetlands when they occur along low terraces and river bars that are flooded during spring runoff and periods of intense rainfall and are vegetated by willows or river beauty (Epilobium latifolium) (Dames & Moore, 1982a).

Threatened or Endangered Species

Three candidate threatened or endangered species have potential for occurrence in the project area (Murray, 1980). These are Kobuk locoweed (Oxytropis kobukensis), the kokrines oxytrope (Oxytropis kokrinensis) and fleabane (Erigeron grandiflorus muirii). However, none of these species were found during extensive field surveys from 1981 to 1983 (Dames & Moore, 1982a, 1983a,b). Thus, it appears unlikely that candidate threatened or endangered species occur in areas proposed for development.

Terrestrial Wildlife

Birds

Three groups of birds are of particular concern in the project area: waterfowl, shorebirds and raptors.

---

* Defined in Glossary.

Waterfowl and Shorebirds

Waterfowl and shorebird use of the project area is centered along the coast during the spring and fall migrations, although coastal and inland breeding occurs. The areas of primary importance to waterfowl and shorebirds are the river delta habitats along the coast, especially those associated with coastal lagoons. The total number of birds staging in these areas is not high in comparison to other areas of the Kotzebue Sound region (Dames & Moore, 1983a). Figure IV-3 shows the most important spring and fall migration staging areas.

During spring migration, the staging areas most heavily used by water-orientated birds are the delta areas of the Singoalik River (Singoalik Lagoon), Asikpak River (Asikpak Lagoon), Kivalina and Wulik Rivers (Kivalina Lagoon), Imikruk Creek (Imikruk Lagoon), Omikviorok River (Ipiavik Lagoon) and Tugak Lagoon. During the fall migration, major staging areas are the deltas of the Kivalina River (Kivalina Lagoon) and the Omikviorok River (Ipiavik Lagoon).

Inland habitats for this species group are found in the extensive riparian low shrub areas, and in the sedge-grass marsh areas associated with ponds in the lowlands of the Kivalina, Wulik and Omikviorok River drainages. A combination of emergent vegetation and open water make these ponds high quality habitat for breeding and molting Canada geese (Branta canadensis).

Raptors

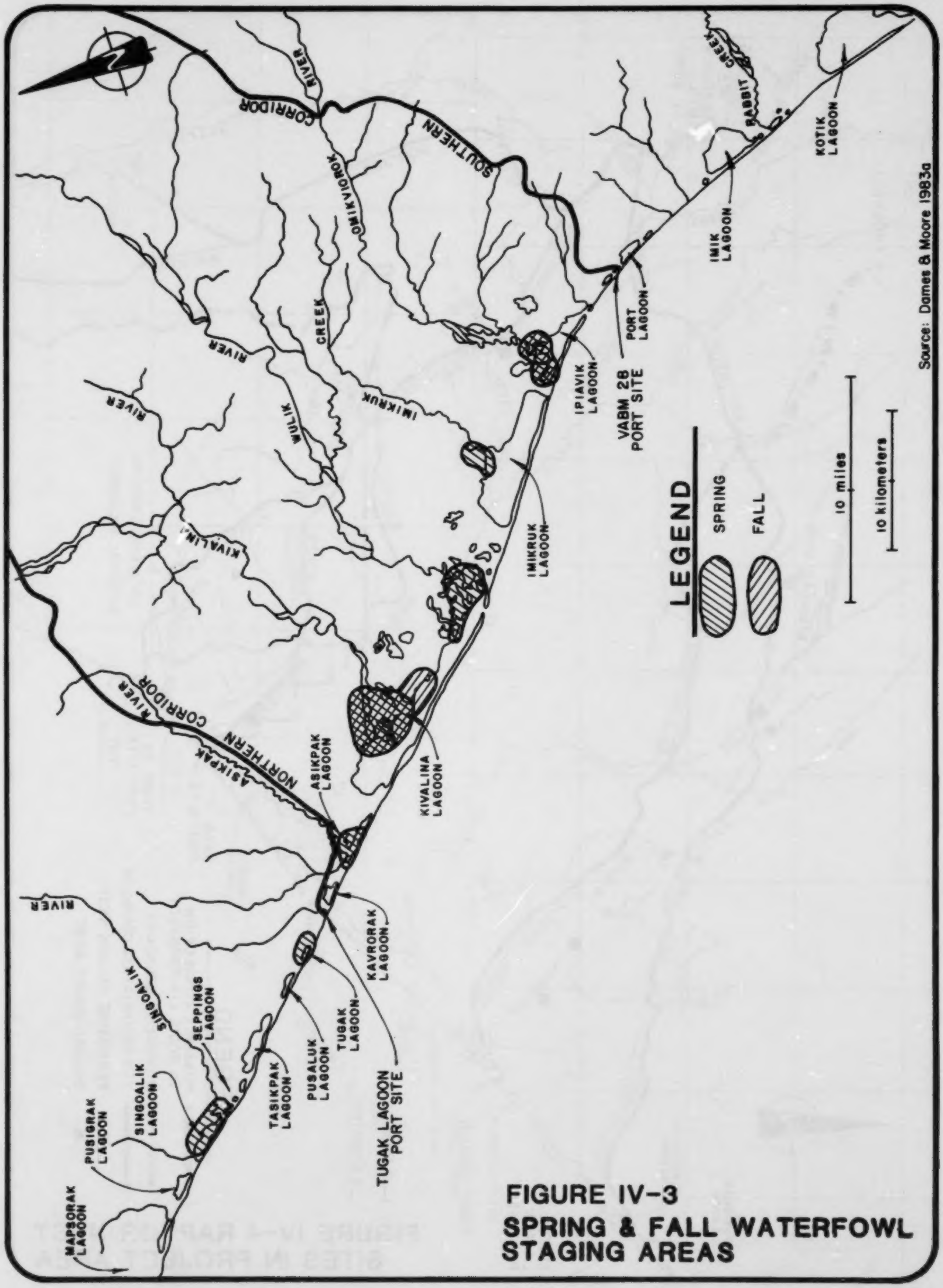
Portions of the project area provide good habitat for cliff nesting raptors including the peregrine falcon (Falco peregrinus), golden eagle (Aquila chrysaetos), gyrfalcon (Falco rusticolus) and the rough-legged hawk (Buteo lagopus). The peregrine falcon is classified as a federally endangered species under the Endangered Species Act, and golden eagle nest sites are protected by the Bald Eagle Protection Act. Peregrine falcon and golden eagle nest sites which have been reported in the vicinity of potential project impact areas (Dames & Moore, 1983a) are shown on Figure IV-4. Additional information on peregrine falcons is included in Appendix 3, Endangered Species Biological Assessment.

Mammals

Five large terrestrial mammal species are found in the project area; caribou (Rangifer tarandus), muskoxen (Ovibos moschatus), moose (Alces alces), Dall sheep (Ovis dalli) and brown bear (Ursus arctos). Other important terrestrial mammal species in the project area include the wolf (Canis lupus), wolverine (Gulo gulo) and red fox (Vulpes vulpes).

Caribou

The western Arctic caribou herd, numbering approximately 190,000 animals and the largest herd in North America, encompasses the project area within its range. A small portion of this herd uses the Singoalik, Asikpak, Kivalina, Wulik and Omikviorok River drainages for winter range, while the large majority of the herd moves further south and eastward to overwinter.


SOUTHERN CORRIDOR
NORTHERN CORRIDOR
OMIKVIOROK RIVER
RABBIT CREEK
KOTIK LAGOON
IMIK LAGOON
PORT LAGOON
VABM 28 PORT SITE
IPIAVIK LAGOON
IMIKRUK
IMIKRUK LAGOON
WULIK
CREEK
RIVER
RIVER
KIVALINA
KIVALINA LAGOON
ASIKPAK RIVER
ASIKPAK LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
PUSALUK LAGOON
TASIKPAK LAGOON
SEPPINGS LAGOON
SINGOALIK RIVER
SINGOALIK LAGOON
PUSIGRAK LAGOON
MAPSORAK LAGOON
LEGEND
SPRING
FALL
10 miles
10 kilometers

Source: Dames & Moore 1983a

FIGURE IV-3

SPRING & FALL WATERFOWL STAGING AREAS

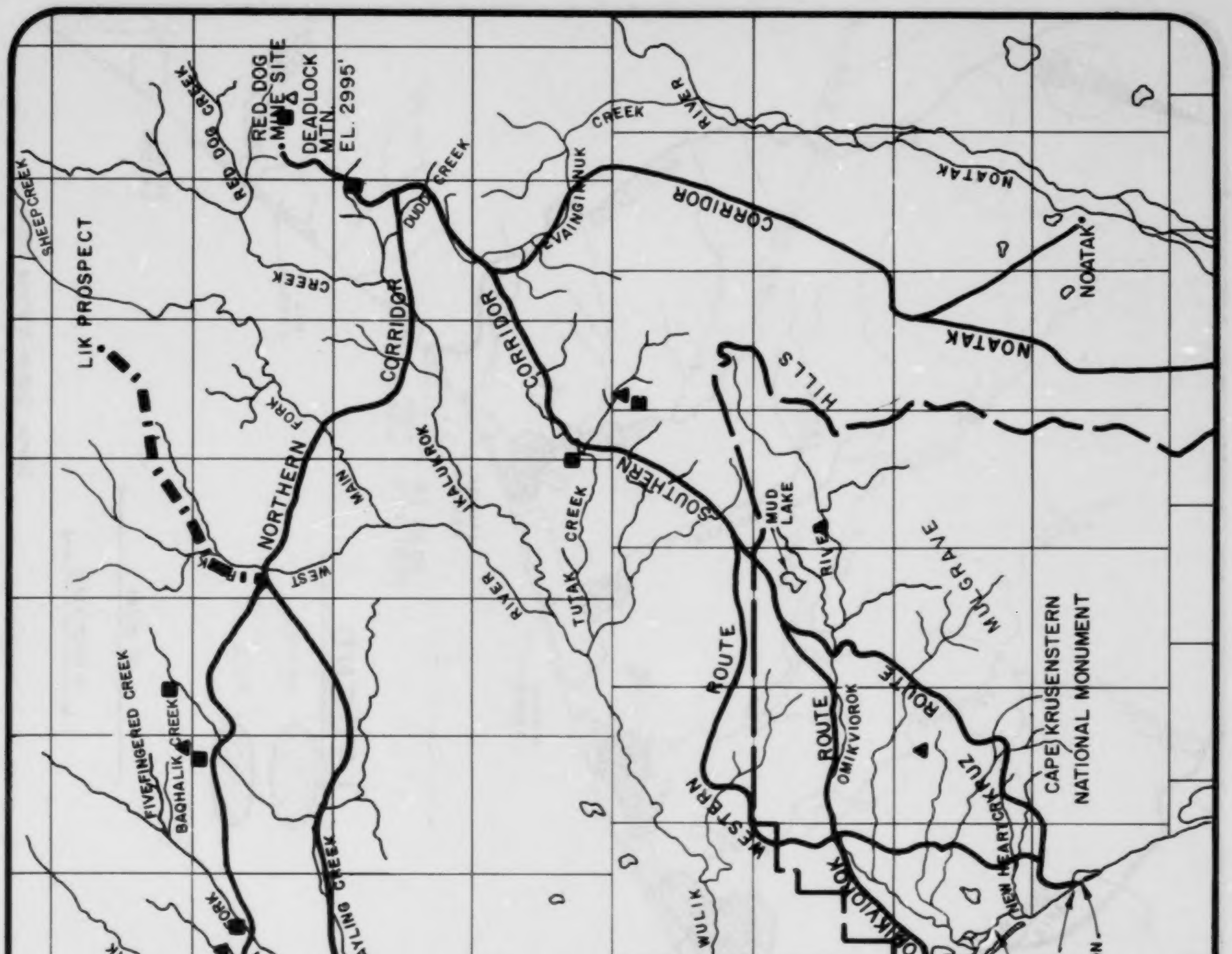

LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
PEREGRINE FALCON NEST
GOLDEN EAGLE NEST
6 miles
10 kilometers
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
RED DOG CREEK
SHEEP CREEK
LIK PROSPECT
CREEK
DUDD CREEK
IVAINGTIVNUK CREEK
NOATAK RIVER
NOATAK
CORRIDOR
NORTHERN
SOUTHERN
HILLS
FORK
MAIN
WEST
IKALUKROK
TUTAK CREEK
RIVER
MUD LAKE
MULGRAVE
ROUTE
WESTERN
OMIKVIOROK
KRUZ
NEW HEART CR.
CAPE KRUSENSTERN NATIONAL MONUMENT
FIVEFINGERED CREEK
BAGHALIK CREEK
GRAYLING CREEK
WULIK
KIVALINA
GCO
ASIKPAK
SINGOALIK
PUSIGRAK LAGOON
SINGOALIK LAGOON
SINGOALIK LAGOON PORT SITE
TUGAK LAGOON
TUGAK LAGOON PORT SITE
KAVRORAK LAGOON
KIVALINA LAGOON
CHUKCHI SEA
IMIKRUK LAGOON
VABM 17 PORT SITE
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON

FIGURE IV-4 RAPTOR NEST SITES IN PROJECT AREA

Winter distribution in the project area, both in numbers and location, is highly variable and probably dependent on local weather conditions (e.g., snow depth). Winter numbers in these drainages may reach 10,000 individuals in some years (Dames & Moore, 1983a). Figure IV-5 shows the historical caribou winter range within the project area since 1966 (Ott, 1983), as well as the more specific primary and secondary habitats used by caribou from 1981 to 1983 (Dames & Moore, 1983a).

In the spring, caribou leave winter ranges in the project area and migrate north through the De Long Mountains to their traditional calving grounds on the Arctic Slope. Relatively few animals normally remain in the vicinity of the project area during late spring and early summer, but in early July 1982 approximately 10,000 bulls were observed there (Ott, 1983). In early July a large movement of caribou numbering in the tens-of-thousands normally enters the project area from the northwest, and passes through the upper drainages of the Kivalina and Wulik Rivers in the traditional counter-clockwise post-calving aggregation. These animals then return to the Arctic Slope to spend the remainder of the summer. Caribou normally enter the Wulik and Kivalina drainages again in late fall, primarily from the northwest. In some years this movement may involve a large portion of the western Arctic herd (e.g., in 1975 an estimated two-thirds of the entire herd passed through the project area during the fall on their migration to wintering areas to the south and east).

Muskoxen

Muskoxen appear to be slowly increasing in numbers in the region following introductions at several locations during the past 13 years. A herd of at least eight animals appears to be established on winter range in the Rabbit Creek valley south of the Mulgrave Hills. A larger herd is established to the northwest in the Cape Thompson area, and some individuals probably use the Singoalik River Valley as part of their home range. During the late spring, summer and fall, the animals appear to range widely along the coast, and inland in the Singoalik, Asikpak, Kivalina and Wulik River drainages.

Moose

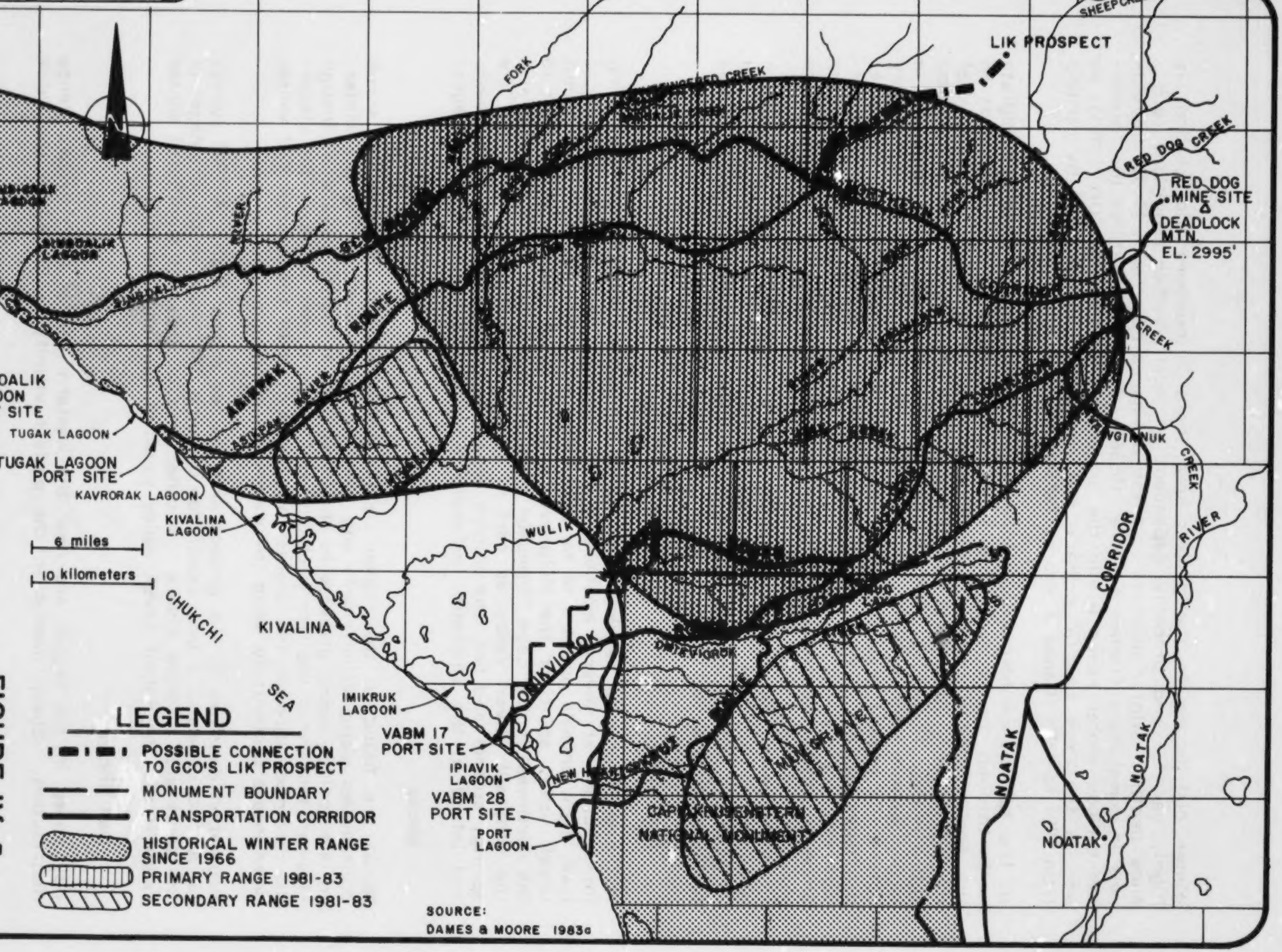
Moose are found in the region closely associated with riparian tall shrub communities along major rivers and streams, particularly during the winter. In late spring, moose disperse to shrub habitats at higher elevations, though riparian tall shrub habitats probably still support most moose. This dispersal continues through the summer and autumn, until the approach of winter when moose concentrate along the waterways again.

Population densities in the project area do not appear high. A 1980 survey by ADF&G estimated a total population of about 150 moose in the drainages of the Wulik and Kivalina Rivers. Another area of apparent significant winter range use is the Rabbit Creek valley south of the Mulgrave Hills.

Dall Sheep

Dall sheep in the region are near the western limit of their Brooks Range distribution. Sheep habitat in the project vicinity is limited to the Wulik

Reproduced from
best available copy.


LIK PROSPECT
SHEEPCREEK
RED DOG CREEK
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
FORK
CREEK
IVGINNUK
CREEK
RIVER
CORRIDOR
NOATAK
NOATAK
NOATAK
WULIK
KIVALINA
CHUKCHI SEA
SINGOALIK LAGOON PORT SITE
TUGAK LAGOON
TUGAK LAGOON PORT SITE
KAVRORAK LAGOON
KIVALINA LAGOON
IMIKRUK LAGOON
VABM 17 PORT SITE
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
CAPE KRUSENSTERN NATIONAL MONUMENT
6 miles
10 kilometers
LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
HISTORICAL WINTER RANGE SINCE 1966
PRIMARY RANGE 1981-83
SECONDARY RANGE 1981-83

SOURCE:
DAMES & MOORE 1983a

FIGURE IV-5
CARIBOU WINTER RANGE

Peaks and the mountains bordering the headwaters of the Wulik River and Ikalukrok Creek (Fig. IV-6). Sheep are generally found in low to moderate numbers in these areas.

Brown (Grizzly) Bears

Brown bears are found throughout the project area. They occupy several different habitats depending on the season and availability of food. In spring the upper mountainous areas appear to be favored, while the lowland/ coastal areas are favored in the summer and fall. The bears tend to move toward spawning streams when fish are present, and bears have been observed along the Wulik River, Ikalukrok Creek and the Asikpak River. Denning probably occurs throughout the region at higher elevations, and the Siaktak Hills area on the Asikpak River is known to support several dens.

Wolf

Wolves occur throughout the project area in moderate numbers and are an important ungulate* predator in the region. They are eagerly hunted and trapped by local residents for their pelts. Single animals and packs of up to 12 wolves have been reported by Red Dog Camp personnel (Dames & Moore, 1983a).

Wolverine

The wolverine is a wide-ranging species that presently occurs throughout the project area in moderate numbers. They are also important to hunters and trappers in the region for their pelts.

Red Fox

Red fox are found throughout the region and occur in a variety of habitats. Their abundance fluctuates and the population within the project area appears to be low to moderate at present. They are also an important species for local trappers.

Threatened or Endangered Species

The only threatened or endangered terrestrial animal species within the project area is the endangered peregrine falcon. Dames & Moore (1983a) reported seven nest sites (Fig. IV-4) and several other observations of birds not associated with nests. During 1983, a survey of the previously identified peregrine nest sites did not find any active peregrine nests (Dames & Moore, 1983b). Additional information may be found in Appendix 3 (Endangered Species Biological Assessment).

Groundwater Resources

The volume and distribution of groundwater is dependent upon the geology and soils of an area and is controlled by seasonal permafrost depths. Groundwater may occur above (suprapermafrost water), within (intrapermafrost water) or below (subpermafrost water) the permafrost layer (Muller,

---

* Defined in Glossary.

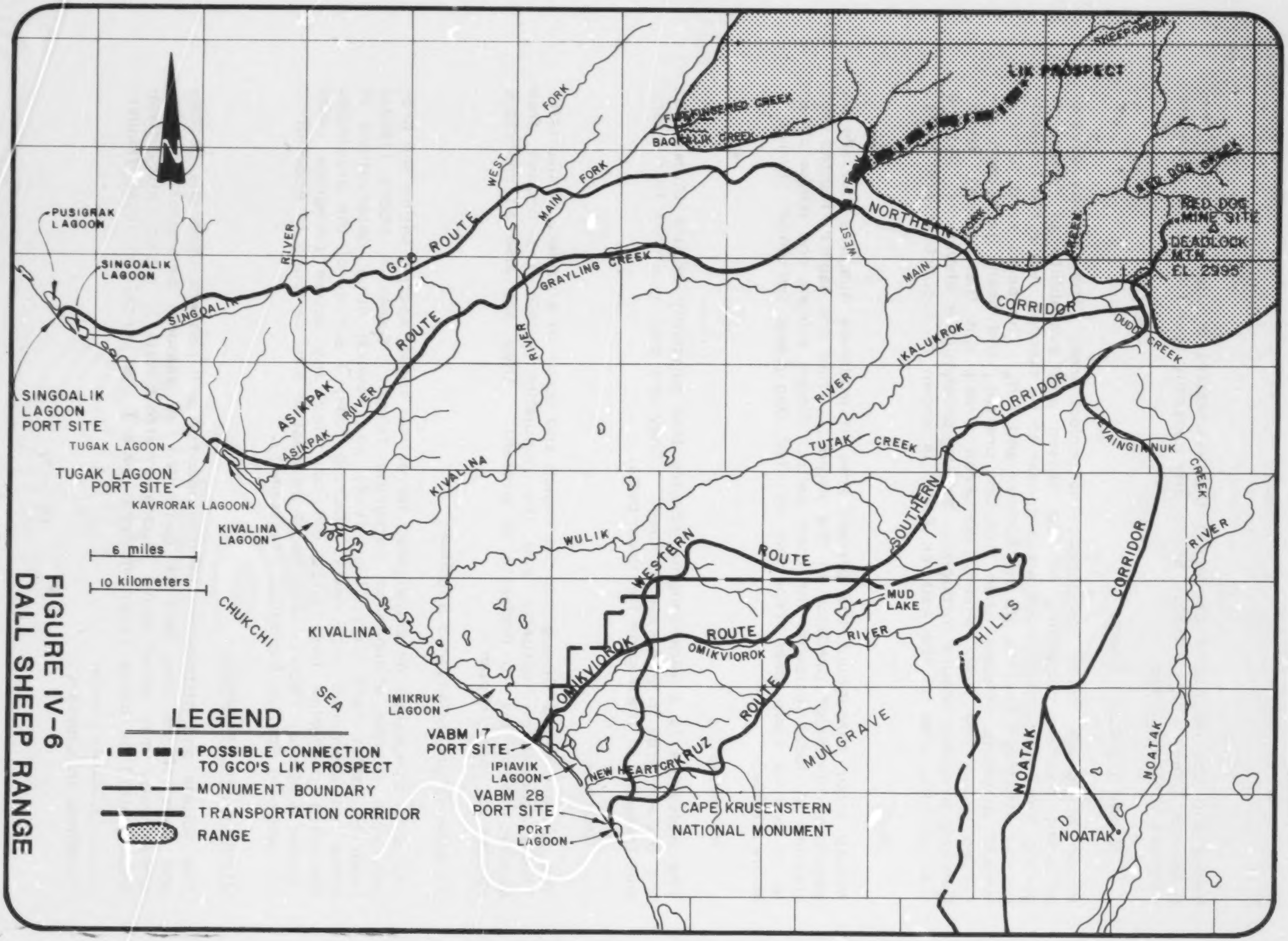

LIK PROSPECT
SHEEP CREEK
FIVE FINGERED CREEK
BAQ'ALIK CREEK
RED DOG CREEK
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
WEST FORK
MAIN FORK
GCO ROUTE
GRAYLING CREEK
ROUTE
ASIKPAK RIVER
SINGOALIK RIVER
PUSIGRAK LAGOON
SINGOALIK LAGOON
SINGOALIK LAGOON PORT SITE
TUGAK LAGOON
TUGAK LAGOON PORT SITE
KAVRORAK LAGOON
KIVALINA LAGOON
KIVALINA RIVER
KIVALINA
WULIK RIVER
IKALUKROK RIVER
TUTAK CREEK
DUDD CREEK
EVAINGIINUK CREEK
WESTERN ROUTE
OMIKVIOROK ROUTE
KRUZ ROUTE
NEW HEART CR.
MUD LAKE
HILLS
MULGRAVE
NOATAK RIVER
NOATAK
CHUKCHI SEA
IMIKRUK LAGOON
VABM 17 PORT SITE
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
CAPE KRUSENSTERN NATIONAL MONUMENT
6 miles
10 kilometers
N
LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
RANGE

FIGURE IV-6
DALL SHEEP RANGE

IV-18

1947). At this time, permafrost depths in the project area have not been ascertained. Sources of groundwater include surface recharge by percolation through unfrozen bedrock fractures, and infiltration of surface runoff through thawed surficial soils.

Relatively small quantities of groundwater exist within the bedrock and soil deposits in the Red Dog Creek valley. It is estimated that groundwater wells would produce less than 83 ℓ/min (10 gal/min) (Balding, 1976; Fuelner et al., 1971). Groundwater flows through unfrozen bedrock fractures generally follow topographic slopes. Groundwater movements through unfrozen, suprapermafrost soils are closely associated with surface water flows, and eventually discharge into Red Dog Creek.

Most of the groundwater encountered in the project area is ephemeral and occurs only during warmer months when the active soil layer is thawed. The availability of year-round groundwater is likely to depend on the thickness of the alluvial layer beneath streams in relation to the depth of winter freezing and the top of the permafrost layer. Small quantities of groundwater may exist throughout the year as evidenced by icings and pressure ridges observed on the ice-covered creeks (Dames & Moore, 1983a).

Groundwater samples have been collected from two small seeps located along Red Dog Creek. In general, these seep samples had substantially lower pH and temperature, and higher levels of conductivity than Red Dog Creek. Water samples from the seeps were worse than EPA aquatic life water quality standards for cadmium, copper, iron, lead, nickel, phosphorous and zinc. The high metals content of these seeps indicates that their source is from within the ore zone. The mechanism of groundwater movement and residence time within the ore zone is not known.

Freshwater Resources

Hydrology

The project area is located primarily within the drainage basins of three major rivers: the Kivalina, Wulik and Omikviorok (Fig. III-2). A small portion of the area is also located in the upper reaches of the Noatak River drainage basin. The Kivalina River, in the western portion of the project area, originates in the Wulik Peaks at the western end of the De Long Mountains and flows southwest to enter the Chukchi Sea approximately 10 km (6 mi) northwest of the Native community of Kivalina. River crossings of the Kivalina would be required at three locations along the northern transportation corridor. The northern corridor also crosses the Asikpak River, which is a much smaller drainage entering the Chukchi Sea northwest of Kivalina Lagoon.

Most of the project area is located within the Wulik River basin. The Wulik River drains the western De Long Mountains and flows approximately 128 km (80 mi) southwest before entering the Chukchi Sea at Kivalina.

The proposed mine and mill facilities are located in the drainage basin of Red Dog Creek. This creek is a tributary of Ikalukrok Creek which is a major tributary of the Wulik River (Fig. IV-2). The northern transportation corridor crosses both Ikalukrok Creek and the Wulik River. The eastern end of the southern transportation corridor crosses small tributaries of Ikalukrok Creek, and small portions of the upper Wulik and Noatak River watersheds.

The western end of the southern transportation corridor traverses the Omikviorok River basin, and may require a major bridge across this river depending on the final routing. The Omikviorok River is considerably smaller than the Wulik River. It drains the coastal uplands on the north side of the Mulgrave Hills before flowing west to enter the Chukchi Sea at Ipiavik Lagoon.

Limited flow data are available for these rivers and their tributaries. The USGS has published data for two streams which provide representative seasonal flow characteristics in the De Long Mountains region. These are the Noatak River, whose much larger river basin is east of the Wulik River, and Ogotoruk Creek, which is located approximately 65 km (40 mi) northwest of Kivalina. Table IV-1 summarizes the estimated annual flow characteristics for streams in the project area based upon these records and other sources of information on precipitation.

Mean annual runoff for streams in the project area varies from 0.01 to 0.02 $m^3/sec/km^2$ (1.1 to 1.9 $ft^3/sec/mi^2$). This corresponds to basin runoff of 30 to 64 cm/yr (12 to 25 in/yr) and mean basin precipitation of 38 to 76 cm/yr (15 to 30 in/yr). The lowest annual runoff is in coastal lowland locations and the highest in the De Long Mountains.

Seasonal flow changes in Arctic streams are much greater than those typical of temperate climates. Virtually all streamflow occurs between breakup and freezeup, a period of approximately five months from the middle of May through the middle of October. Streams generally exhibit two periods of high flow: at spring breakup and during summer and fall storm events. Typical proportions of mean monthly runoff for rivers in the study area are shown in Table IV-2.

Smaller tributaries freeze to the bottom in winter. Some springs continue to flow during the winter months, but generally form icings a short distance away. Major rivers continue to flow through the winter, but accurate flow measurements are difficult to determine because of the imprecision associated with determining under-ice flow.

The presence of shallow permafrost and saturated soils results in a rapid response between snowmelt or rainfall and the resulting stream discharge. Over 80 percent of annual peak floods occur during the breakup period in May and June. All other floods result from intense summer rain events. The 100-year recurrence flood is 0.547 to 1.641 $m^3/s/km^2$ (50 to 150 $ft^3/s/mi^2$) for drainage areas of 2,589 to 259 km^2 (1000 to 100 mi^2) (Childers et al., 1979). Smaller tributaries in the De Long Mountains have larger peak runoff rates per square mile than major streams. Ten-year and 100-year recurrence flood peaks for locations in Red Dog Valley are shown in Table IV-3.

Table IV-1

MEAN ANNUAL FLOW DATA FOR SOME STREAMS IN THE RED DOG MINE PROJECT AREA

Location	Drainage Area		Mean Annual Runoff					
	km^2	mi^2	cm	in	m^3/s	ft^3/s	m^3/s/km^2	ft^3/s/mi^2
Kivalina River at Chukchi Sea	1,740	672	41	16	22.6	800	0.013	1.2
Wulik River at Chukchi Sea	2,339	903	46	18	34.0	1,200	0.014	1.3
Omikviorok River at Chukchi Sea	469	181	38	15	5.7	200	0.012	1.1
Ikalukrok Creek at Wulik River	492	190	48	19	7.6	270	0.015	1.4
Ikalukrok Creek above Red Dog Creek	153	59	61	24	3.1	110	0.020	1.9
Red Dog Creek at Ikalukrok Creek	65	25	48	19	1.0	35	0.015	1.4
North Fork Red Dog Creek at Main Fork	36	14	48	19	0.6	20	0.017	1.4
Main Fork Red Dog Creek above South Fork	13	5	51	20	0.2	7	0.015	1.4
South Fork Red Dog Creek at Main Fork	8	3	48	19	0.1	4	0.012	1.3
Main Fork Red Dog Creek above North Fork	23	9	48	19	0.4	13	0.017	1.4
Bons Creek at Water Supply Dam Site	10	4	48	19	0.2	6	0.020	1.5

Table IV-2

TYPICAL MEAN MONTHLY FLOW PROPORTIONS FOR RED DOG PROJECT STUDY AREA STREAMS

Month	Mean Monthly Flow Proportion
October	3.0%
November	1.0%
December	0.5%
January	0.5%
February	0.5%
March	0.5%
April	1.0%
May	7.0%
June	32.0%
July	22.0%
August	17.0%
September	15.0%

Water Quality

Water quality in the Kivalina and Wulik Rivers is typical of unpolluted fresh water in the Arctic. Both of these rivers are clear water streams with low levels of color, suspended solids, turbidity and nutrients. The water is highly oxygenated, moderately hard to hard, and classified as a calcium bicarbonate type. The pH level of these rivers is essentially neutral (7.0 to 8.2), and levels of most trace elements fall within ranges acceptable for freshwater aquatic life. Ikalukrok Creek has similar water quality characteristics to the Kivalina and Wulik Rivers, except below its confluence with the lower quality waters of the Red Dog Creek (Fig. IV-7).

The waters of Red Dog Creek are atypical of most undeveloped Arctic streams because of the toxic concentrations of dissolved elements that enter the main stem of the creek as it flows through the highly mineralized ore body. Waters in the upper portion of the main stem, the North Fork, and

Table IV-3

TEN- AND 100-YEAR RECURRENCE FLOOD FLOWS FOR STREAM LOCATIONS IN RED DOG VALLEY

	Flood Event			
	10-year		100-year	
Location	m^3/s	ft^3/s	m^3/s	ft^3/s
North Fork Red Dog Creek at Main Fork	25.5	900	62.3	2,700
South Fork Red Dog Creek at Main Fork	7.1	250	21.2	750
Main Fork Red Dog Creek above South Fork	11.3	400	28.3	1,000
Bons Creek at Water Supply Dam Site	8.5	300	24.1	850

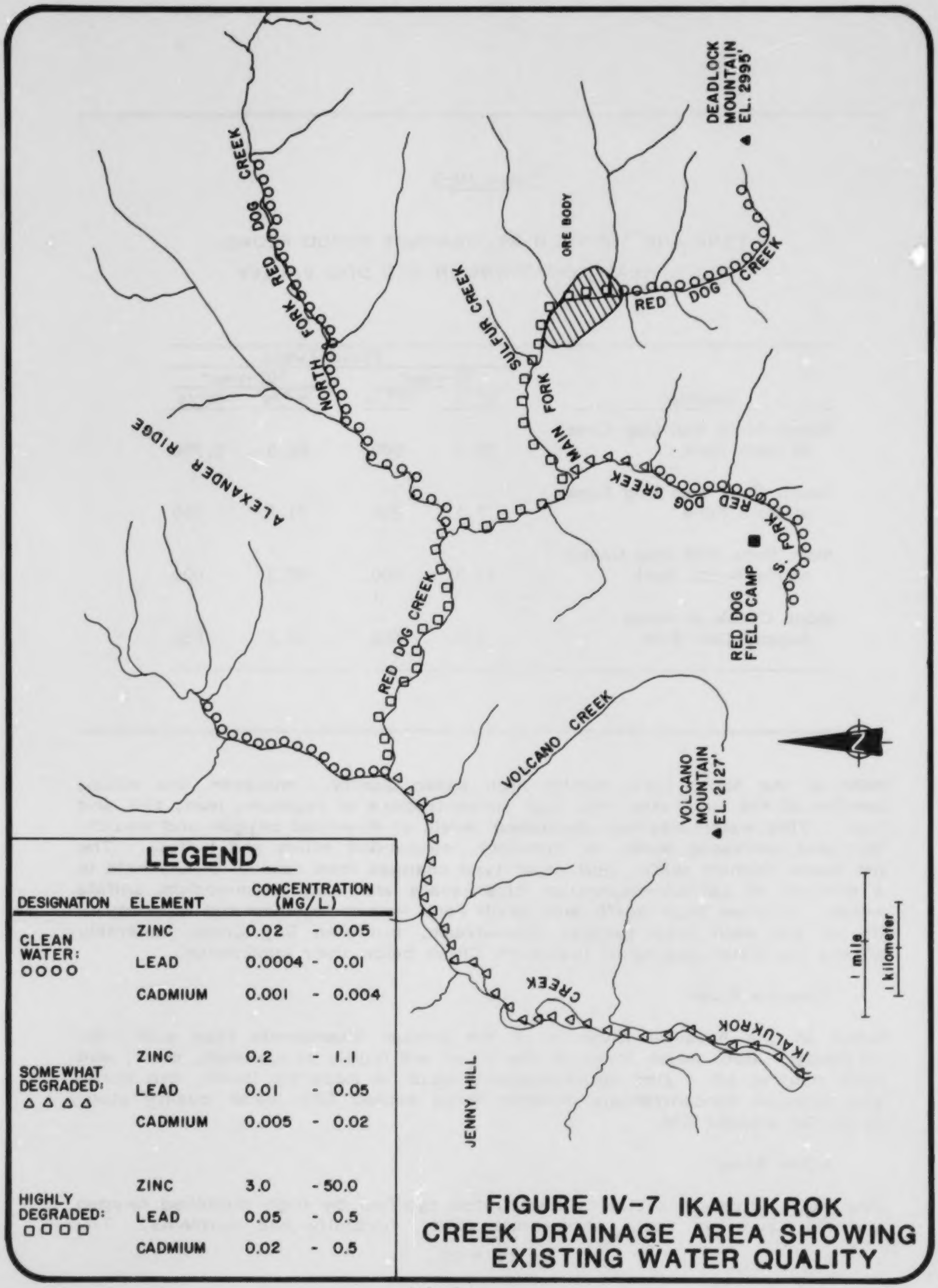
most of the South Fork exhibit high water quality. However, the middle portion of the main stem has high concentrations of cadmium, lead, zinc and iron. This water also has decreased levels of dissolved oxygen and alkalinity, and increased levels of turbidity, suspended solids and sulfate. The pH turns slightly acidic, and water type changes from calcium bicarbonate to a mixture of calcium-magnesium bicarbonate and magnesium-sodium sulfate water. Dilution from North and South Fork waters improves the water quality of the main stem further downstream, but Red Dog Creek adversely affects the water quality of Ikalukrok Creek below their confluence.

Kivalina River

Water in the Kivalina River is of the calcium bicarbonate type with high alkalinity. Both major forks of the river are highly oxygenated, clear, and have neutral pH. Zinc concentrations occur in moderate levels, but boron and cadmium concentrations in both forks exceed EPA water quality standards for aquatic life.

Wulik River

The Wulik River is a clear water system typified by high dissolved oxygen and low levels of color, suspended solids, turbidity and nutrients. The


NORTH FORK RED DOG CREEK
ALEXANDER RIDGE
SULFUR CREEK
ORE BODY
RED DOG CREEK
DEADLOCK MOUNTAIN
EL. 2995'
MAIN FORK RED DOG CREEK
S. FORK RED DOG CREEK
RED DOG FIELD CAMP
RED DOG CREEK
VOLCANO CREEK
VOLCANO MOUNTAIN
EL. 2127'
JENNY HILL
IKALUKROK CREEK
N
1 mile
1 kilometer

LEGEND

DESIGNATION	ELEMENT	CONCENTRATION (MG/L)
CLEAN WATER: ○○○○	ZINC	0.02 - 0.05
	LEAD	0.0004 - 0.01
	CADMIUM	0.001 - 0.004
SOMEWHAT DEGRADED: △△△△	ZINC	0.2 - 1.1
	LEAD	0.01 - 0.05
	CADMIUM	0.005 - 0.02
HIGHLY DEGRADED: □□□□	ZINC	3.0 - 50.0
	LEAD	0.05 - 0.5
	CADMIUM	0.02 - 0.5

FIGURE IV-7 IKALUKROK CREEK DRAINAGE AREA SHOWING EXISTING WATER QUALITY

water is moderately hard, and of the calcium bicarbonate type, with pH ranging from 7.0 to 8.1. Winter water quality values are similar to those measured during open water periods with minor exceptions. Concentrations of barium, cadmium and silver are slightly higher in the winter than in the summer, while iron, sodium and zinc levels are lower in the winter.

Ikalukrok Creek

Except for a short period during breakup, Ikalukrok Creek is a highly oxygenated, clear water stream that exhibits low levels of color, suspended solids, turbidity, ammonia and orthophosphate throughout the year. The water is moderately hard to hard except during breakup when it is soft, and of the calcium bicarbonate type with pH near neutral.

Ikalukrok Creek water quality is significantly affected by Red Dog Creek waters for a considerable distance below their confluence. Water quality parameters such as pH, carbon dioxide, cadmium, lead and zinc show high concentrations at the confluence of the two streams, but gradually decrease to typical low levels downstream of the confluence as a result of tributary and groundwater dilution. Seasonal flows and concentrations of total zinc, lead and cadmium are shown in Tables IV-4, IV-5 and IV-6. Figure IV-7 shows the extent of degraded water quality due to high concentrations of zinc, lead and cadmium.

Dudd, Buddy and Bons Creeks

Water quality in these creeks is generally very good during breakup, summer and early winter. Water is of the calcium bicarbonate type, low in turbidity and settleable solids and highly oxygenated. With the exception of cadmium levels in Bons Creek during breakup, concentrations of aluminum, copper, lead, silver and zinc are better than EPA water quality standards for aquatic life in all three creeks throughout the year.

North Fork Red Dog Creek

This creek is a high quality, clear water stream with high dissolved oxygen levels during summer and breakup, and low levels of suspended solids, turbidity and settleable solids throughout the year. Water is of the calcium-magnesium bicarbonate type with elevated levels of sulfate, and normal ranges of pH, alkalinity and conductivity. Concentrations of cadmium, lead and silver are slightly above recommended EPA water quality criteria for aquatic life, but much lower than concentrations observed in the South and Main Forks of Red Dog Creek. Typical concentrations of total zinc, lead and cadmium are shown in Tables IV-4, IV-5 and IV-6. Figure IV-7 shows that the North Fork is a clean, uncontaminated stream similar to Ikalukrok Creek upstream of Red Dog Creek.

South Fork Red Dog Creek

The water of this fork is generally a mixture of calcium-magnesium bicarbonate type with sodium sulfate type water. Concentrations of cadmium, lead and zinc reach highly toxic levels, while concentrations of mercury, chromium and silver slightly exceed EPA water quality criteria for aquatic life. Alkalinity and pH are generally depressed in this creek, and total dis-

Table IV-4

SEASONAL FLOWS AND CONCENTRATIONS AND LOADS OF ZINC[1] IN PROJECT AREA STREAMS

	SUMMER LOW FLOWS					STORM EVENTS					WINTER FLOWS					SPRING FLOWS				
	Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load	
DRAINAGE BASIN	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day
Middle Fork Red Dog Creek Above South Fork	0.2	7	19.0	326	718	0.9	30	12.0	882	1,944	0.01	0.5	50.0	61	135	0.7	25	6.0	368	810
South Fork Red Dog Creek	0.1	4	0.9	8.6	19	0.6	20	1.1	54	119	0.01	0.5	1.0	1.4	3	0.4	15	0.2	7.3	16
North Fork Red Dog Creek and Lower Basin	0.7	24	0.02	1.4	3	2.1	75	0.04	7.3	16	0.08	3.0	0.02	0.5	1	2.2	77	0.05	9.5	21
Red Dog Creek	1.0	35	4.0	343	756	3.5	125	3.0	919	2,025	0.11	4.0	7.0	68	151	3.5	125	1.3	398	878
Ikalukrok Creek Above Red Dog Creek	3.1	110	0.02	5.4	12	11.6	410	0.025	25	55	0.3	11.0	0.05	1.4	3	8.5	300	0.025	18	41
Ikalukrok Creek Below Red Dog Creek	4.1	145	1.0	355	783	15.2	535	0.7	918	2,022	0.4	15.0	1.7	63	138	12.0	425	0.4	416	918
Ore Zone Load in Ikalukrok Creek				93 percent					93 percent					89 percent					88 percent	

Source: Dames & Moore, 1983a

[1] EPA Water Quality Criteria for Aquatic Life: 0.047 mg/ℓ

Table IV-5

SEASONAL FLOWS AND CONCENTRATIONS AND LOADS OF LEAD[1] IN PROJECT AREA STREAMS

	SUMMER LOW FLOWS					STORM EVENTS					WINTER FLOWS					SPRING FLOWS				
	Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load	
DRAINAGE BASIN	m³/s	ft³/s	mg/ℓ	kg/day	lb/day	m³/s	ft³/s	mg/ℓ	kg/day	lb/day	m³/s	ft³/s	mg/ℓ	kg/day	lb/day	m³/s	ft³/s	mg/ℓ	kg/day	lb/day
Middle Fork Red Dog Creek Above South Fork	0.2	7	0.1	1.7	3.8	0.9	30	0.3	22	49	0.01	0.5	0.05	0.05	0.1	0.7	25	0.5	31	68
South Fork Red Dog Creek	0.1	4	0.02	0.2	0.4	0.6	20	0.04	2.0	4.3	0.01	0.5	0.01	0.01	0.03	0.4	15	0.05	1.9	4.1
North Fork Red Dog Creek and Lower Basin	0.7	24	0.001	0.05	0.1	2.1	75	0.0005	0.09	0.2	0.08	3.0	0.001	0.01	0.02	2.2	77	0.0005	0.09	0.2
Red Dog Creek	1.0	35	0.007	0.6	1.3	3.5	125	0.04	12	27	0.11	4.0	0.004	0.05	0.1	3.5	125	0.03	9.2	20
Ikalukrok Creek Above Red Dog Creek	3.1	110	0.0004	0.09	0.2	11.6	410	0.001	1.0	2.2	0.3	11.0	0.0005	0.01	0.03	8.5	300	0.001	0.7	1.6
Ikalukrok Creek Below Red Dog Creek	4.1	145	0.002	0.7	1.6	15.2	535	0.01	13	29	0.4	15.0	0.001	0.05	0.1	12.0	425	0.01	10	23
Ore Zone Load In Ikalukrok Creek				88 percent					92 percent					90 percent					88 percent	

Source: Dames & Moore, 1983a

[1] EPA Water Quality Criteria for Aquatic Life: 0.00075 mg/ℓ

Table IV-6

SEASONAL FLOWS AND CONCENTRATIONS AND LOADS OF CADMIUM[1] IN PROJECT AREA STREAMS

	SUMMER LOW FLOWS					STORM EVENTS					WINTER FLOWS					SPRING FLOWS				
	Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load		Flow		Conc.	Load	
DRAINAGE BASIN	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day	m^3/s	ft^3/s	mg/ℓ	kg/day	lb/day
Middle Fork Red Dog Creek Above South Fork	0.2	7	0.14	2.4	5.3	0.9	30	0.1	7.4	16	0.01	0.5	0.5	0.6	1.4	0.7	25	0.05	3.1	6.8
South Fork Red Dog Creek	0.1	4	0.008	0.09	0.2	0.6	20	0.005	0.2	0.5	0.01	0.5	0.007	0.05	0.1	0.4	15	0.01	0.4	0.8
North Fork Red Dog Creek and Lower Basin	0.7	24	0.003	0.2	0.4	2.1	75	0.002	0.4	0.8	0.08	3.0	0.004	0.05	0.1	2.2	77	0.002	0.4	0.8
Red Dog Creek	1.0	35	0.03	2.6	5.7	3.5	125	0.025	7.7	17	0.11	4.0	0.08	0.8	1.7	3.5	125	0.01	3.1	6.8
Ikalukrok Creek Above Red Dog Creek	3.1	110	0.001	0.3	0.6	11.6	410	0.001	1.0	2.2	0.3	11.0	0.002	0.05	0.1	8.5	300	0.001	0.7	1.6
Ikalukrok Creek Below Red Dog Creek	4.1	145	0.008	2.9	6.3	15.2	535	0.007	9.2	20	0.4	15.0	0.02	0.7	1.6	12.0	425	0.0035	3.6	8.0
Ore Zone Load In Ikalukrok Creek				84 percent					85 percent					82 percent					81 percent	

Source: Dames & Moore, 1983a

[1] EPA Water Quality Criteria for Aquatic Life: 0.000012 mg/ℓ

solved solids are elevated compared to other streams outside of Red Dog Valley. Seasonal flows and concentrations of total zinc, lead and cadmium are shown in Tables IV-4, IV-5 and IV-6. Figure IV-7 shows that the South Fork is moderately degraded and does not support fish life.

Main Stem Red Dog Creek

Water in the main stem is of the calcium-magnesium-sodium sulfate type with very high concentrations of dissolved toxic metals. Concentrations of the metals cadmium, lead, silver and zinc greatly exceed EPA water quality criteria for aquatic life. Concentrations of aluminum, chromium, copper, iron, manganese, mercury and nickel also exceed those criteria. Metal concentrations in late winter are particularly high, sometimes an order of magnitude greater than during the open water period. Water in this creek has unusually low pH, low alkalinity and high acidity. Seasonal flows and concentrations of total zinc, lead and cadmium are shown in Tables IV-4, IV-5 and IV-6. Figure IV-7 shows that all of the main stem is highly degraded downstream of the ore body and supports no significant aquatic life.

The upper section of the creek, which lies above the ore body, is relatively uncontaminated with dissolved metals. However, a zone of water quality degradation begins at the upper end of the ore body and extends downstream to the confluence of the main stem with the South Fork. Water quality improves somewhat below this confluence, but downstream levels of metals, turbidity, suspended solids and sulfate continue to remain higher than those found in adjacent streams.

One cause of water quality degradation of the main stem is that the creek flows directly over heavily mineralized rocks. The creek also receives surface and groundwater draining from the ore body area which contains high metals and sulfide concentrations. All parts of the ore body will produce soluble metals by simple dissolution of previously oxidized mineralized zones without significant acid production. These effects are stronger in the main stem of Red Dog Creek compared to the South Fork due to the relative exposure of the ore body to surface runoff. Tables IV-4, IV-5 and IV-6 indicate that 82 to 93 percent of the metal loads in Ikalukrok Creek below the confluence with Red Dog Creek originate from the ore body zone.

Red Dog Creek at Mouth

By the time it enters Ikalukrok Creek, the water quality of Red Dog Creek represents a mixture of the three upstream forks, with the greater flow of the relatively clean North Fork diluting the poorer water quality of the other two forks. The water is a calcium-magnesium bicarbonate type with elevated levels of sulfate, normal pH and alkalinity, and elevated total dissolved solids. Very toxic concentrations of cadmium, lead, silver and zinc are present, and concentrations of aluminum, chromium, mercury and nickel also exceed EPA criteria for aquatic life. Levels of total suspended solids, settleable solids and turbidity are generally low except during breakup and storm events. Alkalinity, carbon dioxide, hardness and conductivity levels are lowest at breakup, and gradually increase throughout the year to reach maximum levels in late winter.

Biology

Invertebrates

Benthic invertebrate fauna in the project area was studied by E.V.S. Consultants in 1982 (E.V.S. Consultants Ltd., 1983). They found that aquatic invertebrate communities typical of cold fast streams occurred on sections of Ikalukrok Creek (sites corresponding to Dames & Moore Stations 8 and 9; Fig. IV-8), on the North and South Forks of Red Dog Creek (Dames & Moore Stations 12 and 22), and in the headwaters of Red Dog Creek above the main ore body (Dames & Moore Station 43). These stations generally had high abundances of organisms, and contributed 70 percent of the total number of individuals sampled at all stations (Fig. IV-8). Midgefly larvae (Chironomidae; subfamilies Diamesinae and Orthocladiinae) were most abundant in these communities. Other abundant taxa included stonefly nymphs (Plecoptera), segmented worms (Oligochaeta*), mayfly nymphs (Ephemeroptera), caddisfly larvae (Trichoptera), blackflies (Simuliidae), dancefly larvae (Empididae), biting midges (Ceratopogonidae), water mites (Hydracarina), seed shrimp (Ostracoda) and roundworms (Nematoda).

The lowest number of individuals was collected along the main stem of Red Dog Creek below the ore body (sites corresponding to Dames & Moore Stations 47, 40, 30, 20 and 10; Fig. IV-8). Although numbers were reduced at these stations, taxa collected were generally similar to those found at stations with greater abundance, and included stoneflies, mayflies, oligochaetes, midgeflies and water mites. Taxa absent at those sites in Red Dog Creek with reduced abundance included roundworms, seed shrimp, mayflies (Family Heptageniidae) and oligochaetes (Family Tubificidae).

The distribution of sites with reduced numerical abundance along Red Dog Creek coincided with areas of elevated heavy metal concentrations near the ore body. The most severely stressed area in terms of reduced numbers of benthic invertebrate individuals and taxa extended from the ore body (Dames & Moore Station 47) downstream nearly to the confluence of Red Dog and Ikalukrok Creeks (Dames & Moore Station 10). The site with the least numerical abundance of invertebrates occurred at Dames & Moore Station 30 near the confluence of the main stem and South Fork of Red Dog Creek (Fig. IV-8).

Toxic metal effects on aquatic invertebrate populations may be a result of direct physiological toxicity, or an indirect result of the elimination of food sources (algae, bacteria, zooplankton) or microhabitat (algal mats, mosses). Specht (1973) found a significant inverse correlation between the concentration of toxic metals and numbers of taxa and individuals in a receiving stream. Data from Red Dog Creek show a similar trend of decreased numerical abundance as metals concentrations increase in the stream.

---

* Defined in Glossary.

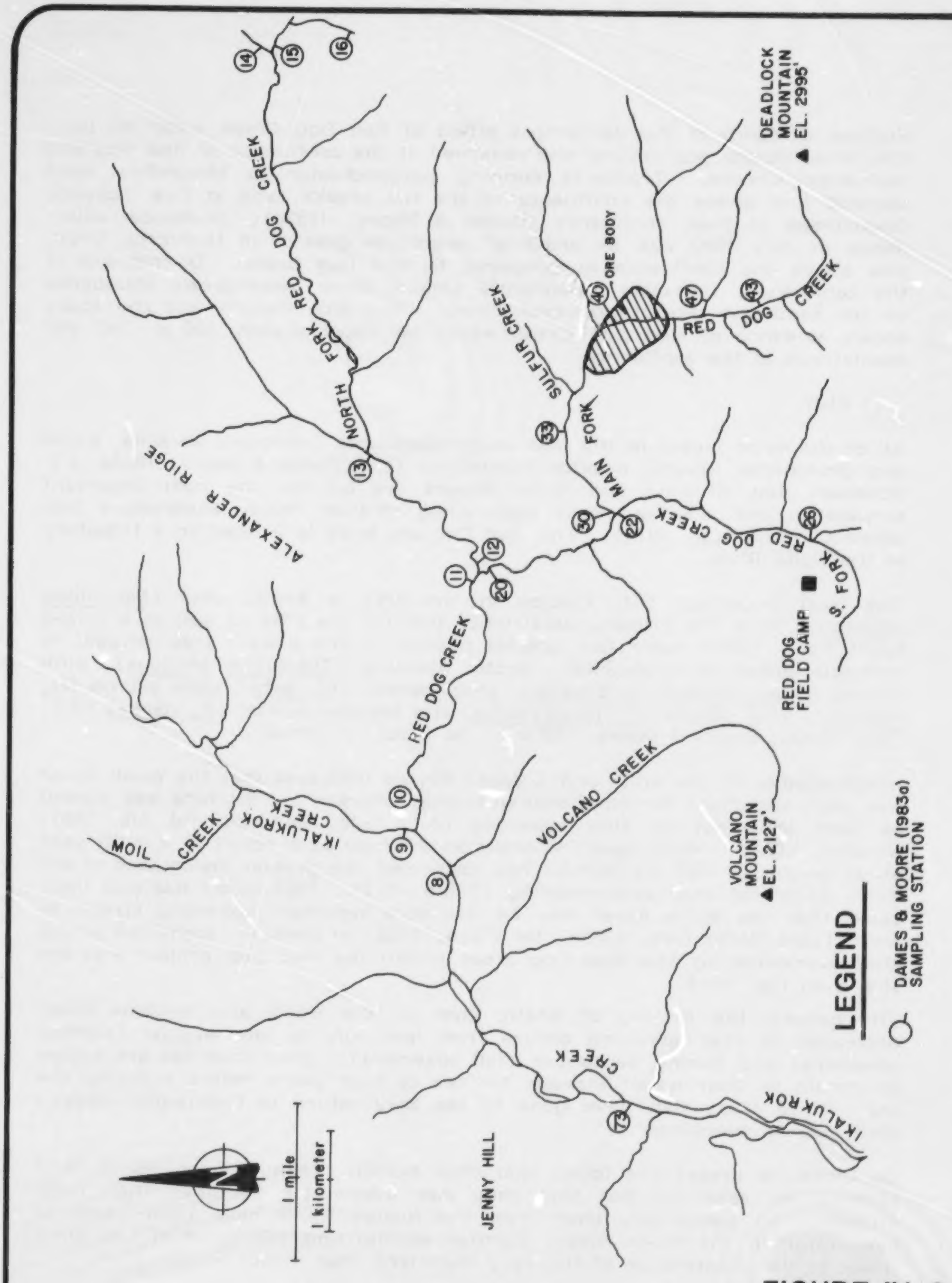

DEADLOCK MOUNTAIN
▲ EL. 2995'
14
15
16
RED DOG CREEK
NORTH FORK
SULFUR CREEK
ORE BODY
40
47
43
RED DOG CREEK
33
MAIN FORK
13
ALEXANDER RIDGE
30
22
RED DOG CREEK
26
S. FORK
12
11
20
RED DOG FIELD CAMP
RED DOG CREEK
10
9
8
IKALUKROK CREEK
MOIL CREEK
VOLCANO CREEK
VOLCANO MOUNTAIN
▲ EL. 2127'
LEGEND
○ DAMES & MOORE (1983a) SAMPLING STATION
CREEK
73
IKALUKROK
JENNY HILL
1 mile
1 kilometer
N

FIGURE IV-8
BENTHIC INVERTEBRATE & FISH SAMPLING
STATIONS IN IKALUKROK & RED DOG DRAINAGES

Further evidence of the deleterious effect of Red Dog Creek water on benthic invertebrate populations was observed at the confluence of Red Dog and Ikalukrok Creeks. Transects running perpendicular to streamflow were sampled just above the confluence of the two creeks, and at five locations downstream of their confluence (Dames & Moore, 1983a). Numerical abundance in July 1982 was an order of magnitude greater in Ikalukrok Creek just above the confluence as compared to Red Dog Creek. Downstream of the confluence, transects consistently showed lower invertebrate abundance on the southeast side of Ikalukrok Creek. This side visually and chemically shows evidence of Red Dog Creek water for approximately 500 m (547 yd) downstream of the confluence.

Fish

All of the major rivers in the Red Dog project area (Asikpak, Kivalina, Wulik and Omikviorok Rivers) provide habitat for fish (Dames & Moore, 1983a, b). However, the Kivalina and Wulik Rivers are by far the most important streams in the area and have been designated as "major anadromous fish streams" (Selkregg, 1974). The Red Dog ore body is located on a tributary of the Wulik River.

The most important fish species in the area is Arctic char (Salvelinus alpinus). It is the primary subsistence fish for the area as well as a prized sport fish. Other major fish species present in the project area include, in probable order of abundance: Arctic grayling (Thymallus arcticus), pink salmon (Oncorhynchus gorbuscha), chum salmon (O. keta), coho salmon (O. kisutch), king salmon (O. tshawytscha) and sockeye salmon (O. nerka) (Alt, 1978, 1983a; Dames & Moore, 1983a,b; De Cicco, in press).

Initial studies of the Wulik and Kivalina Rivers indicated that the Wulik River was more important for char overwintering, whereas the Kivalina was viewed as more important for char spawning (Alt, 1978; Bendock and Alt, 1981; Winslow, 1968). More recent information obtained as a result of a multi-year study begun in 1980 by ADF&G has confirmed the greater importance of the Wulik River for char overwintering (Table IV-7). This study has also indicated that the Wulik River may be the more important spawning stream as well (Table IV-8) (Alt, 1983b; De Cicco, 1982, in press). Identified Arctic char overwintering and spawning areas within the Red Dog project area are shown on Fig. IV-9.

The general life history of Arctic char in the Wulik and Kivalina River drainages is that spawning occurs from late July to late August (summer spawners) and during September (fall spawners). Char juveniles are known to remain in their natal* streams for two to four years before entering the sea. Once these fish have gone to sea they return to freshwater streams each year to overwinter.

De Cicco (in press) has found that char exhibit homing tendencies to natal streams for spawning but that they may overwinter in other than natal streams. In particular, char from the Noatak River have been found to overwinter in the Wulik River, further emphasizing the value of the Wulik River to the maintenance of the very important char resource.

---

* Defined in Glossary.

Table IV-7

RESULTS OF AERIAL SURVEY COUNTS FOR OVERWINTERING ARCTIC CHAR IN THE WULIK AND KIVALINA RIVERS, 1968 TO 1982

Year	Wulik River	Kivalina River
1968	90,236	27,640
1969	297,257	--
1976	68,300	12,600
1979	55,030	15,744
1980	113,553	39,692
1981	101,826	45,355
1982	65,581	10,932

Source: De Cicco, in press.

The major char spawning areas in the Wulik drainage are the West Fork, Main Fork, and main stem of the Wulik down to the confluence of Tutak Creek, Ikalukrok Creek and Tutak Creek (Figure IV-9). The major char spawning areas in the Kivalina drainage are the Main Fork and Grayling, Baqhalik and Fivefingered Creeks (Fig. IV-9), even though lower Grayling Creek can be dry during the summer months (Dames & Moore, 1983b). Juvenile Arctic char have been captured in Rabbit and Fivefingered Creeks by E.V.S. Consultants (1983).

In addition to Arctic char occurrence throughout the Wulik River, salmon species spawn in the lower portions of the Wulik. Pink salmon spawn in the lower 8 to 9.6 km (5 to 6 mi) of the river; sockeye salmon spawn below Wulik Forks; and chum salmon spawn in the lower 19 to 22.4 km (12 to 14 mi) of the river, and for approximately 32 km (20 mi) up Ikalukrok Creek (Dames & Moore, 1983a). Coho and king salmon have also been reported in the river (Alt, 1978, 1983a). Non-migratory species present in the Wulik include slimy sculpin (Cottus cognatus), round whitefish (Prosopium cylindraceum), humpback whitefish (Coregonus pidschian), least cisco (C. sardinella), Bering cisco (C. laurettae) and Alaska blackfish (Dallia pectoralis).

Table IV-8

SUMMARY OF NUMBER OF FISH COUNTED IN ADF&G ARCTIC CHAR SPAWNING SURVEYS, 1981 to 1983

	Survey Date			
Wulik River System	8/20/81	8/6-8/82	9/30/82	8/24/83
Main Fork above Sheep Creek	--	--	--	12
Sheep Creek	44	28	59	123
Main Fork, Sheep Creek to Lik Camp	--	--	--	158
Main Fork, Lik Camp to Forks	--	--	--	53
Main Fork	--	73	2	--
West Fork, Falls to Forks	--	133	30	196
Main Stem, Forks to Ikalukrok Mouth	--	--	--	386
Main Stem	129	184	20	--
Wulik below Ikalukrok Creek	--	--	--	8
Ikalukrok Creek	89	60	--	185*
Dudd Creek	--	--	--	16
Tutak Creek	--	--	--	43
Total	262	478	111	1,180
Kivalina River System				
Kivalina River	--	299	40	--
Main Fork	331	--	--	412
West Fork	--	7	0	10
Grayling Creek	106	146	--	183
Main Stem below Forks	40	--	--	90
Baqhalik Creek	51**	--	--	--
Total	528	452	40	695
Omikviorok River	114***	--	--	138

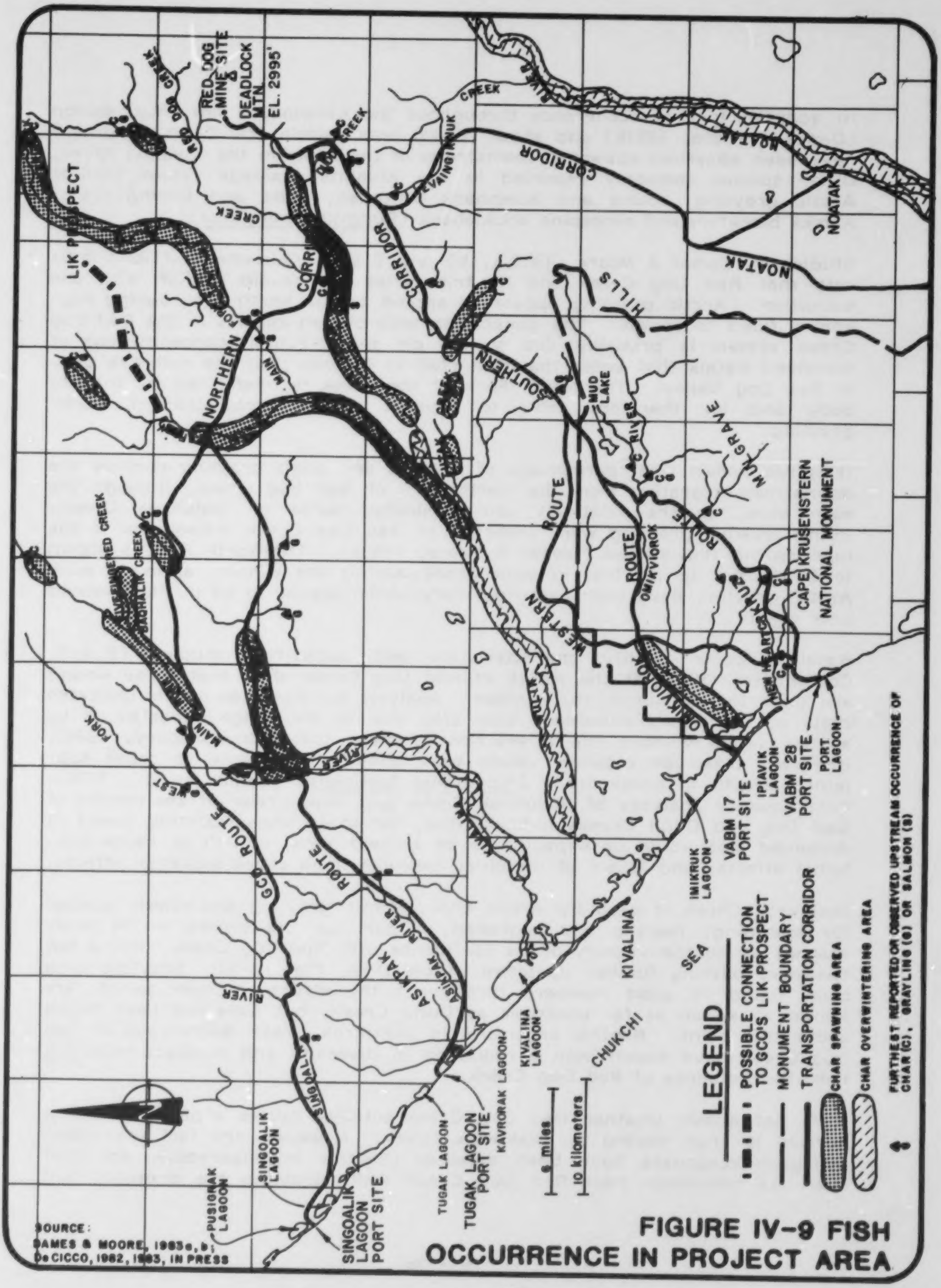
-- Not distinguished or not counted.

* 26 of these were above Red Dog Creek; 19 were between Dudd and Red Dog Creeks.

** 245 char were observed in Baqhalik Creek on 9/25/81

*** Surveyed 7/26/81

Sources: Alt, 1983b; De Cicco, 1982, in press.


LEGEND
POSSIBLE CONNECTION TO GCO'S LIK PROSPECT
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
CHAR SPAWNING AREA
CHAR OVERWINTERING AREA
FURTHEST REPORTED OR OBSERVED UPSTREAM OCCURRENCE OF CHAR (C), GRAYLING (G) OR SALMON (S)
5 miles
10 kilometers
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
RED DOG CREEK
LIK PROSPECT
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
WESTERN ROUTE
GCO ROUTE
NOATAK
NOATAK RIVER
HILLS
MUD LAKE
MULGRAVE
CAPE KRUSENSTERN NATIONAL MONUMENT
OMIKVIOROK RIVER
NEW HEART CREEK
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
VABM 17 PORT SITE
IMIKRUK LAGOON
KIVALINA
KIVALINA LAGOON
KIVALINA RIVER
WULIK RIVER
CHUKCHI SEA
ASIKPAK RIVER
SINGOALIK RIVER
SINGOALIK LAGOON
SINGOALIK LAGOON PORT SITE
PUSIGNAK LAGOON
TUGAK LAGOON
TUGAK LAGOON PORT SITE
KAVRORAK LAGOON
ANXIOUS CREEK
EVAINGIKNUK CREEK
IKALUKROK CREEK
MAIN FORK
WEST FORK
TUTAK CREEK
BUCHAHALIK CREEK
FINGERED CREEK

SOURCE:
DAMES & MOORE, 1983a, b;
DeCICCO, 1982, 1983, IN PRESS

FIGURE IV-9 FISH OCCURRENCE IN PROJECT AREA

In addition to char occurrence throughout the Kivalina, a few chum salmon (Dames & Moore, 1983b) and about 26,000 pink salmon (De Cicco, in press) have been observed spawning downstream of the forks in the Kivalina River. Other species commonly reported in the Kivalina drainage system include Arctic grayling, round and humpback whitefish, least and Bering cisco, Alaska blackfish and ninespine stickleback (Pungitius pungitius).

Studies by Dames & Moore (1983,a, b) and E.V.S. Consultants (1983) indicate that Red Dog Creek and its tributaries are devoid of fish with one exception: Arctic grayling appear to ascend to the North Fork during high spring flows to spawn. The general absence of fish species in the Red Dog Creek system is probably due to low pH and the high concentrations of dissolved metals that enter the main stem as it flows past the main ore body in Red Dog Valley. The North Fork of the creek is unaffected by the ore body and is, therefore, able to support a small population of Arctic grayling.

It is not known what percentage of juvenile and adult grayling survive the downstream migration from the North Fork of Red Dog Creek, through the main stem, to the relatively uncontaminated water of Ikalukrok Creek. Dying juvenile grayling were observed in Red Dog Creek subsequent to the high spring flow period (Dames & Moore, 1983a). The North Fork is known to be frozen to its bed in some areas during the winter, although some Arctic grayling have been captured there which appear to be in their second year of life.

Baseline water quality characteristics and caged-fish studies (E.V.S. Consultants, 1983) at the mouth of Red Dog Creek show that these waters are toxic to fish during the summer. Analysis for dissolved metals indicated that, of the metals examined, only zinc was in the range expected to be acutely lethal without the interaction of other toxicants (Gregory, 1974). However, dissolved cadmium values were above those found to cause sublethal effects to brook trout (Salvelinus fontinalis) (Benoit et al., 1976). Water quality analyses of Ikalukrok Creek just downstream of the mouths of Red Dog and Dudd Creeks indicate that, for these sites, existing levels of dissolved zinc would be expected to be acutely lethal to fish or cause sublethal effects, and levels of dissolved cadmium could cause sublethal effects.

Ikalukrok Creek is used by Arctic char, Arctic grayling and salmon species for spawning, rearing and migration. Char use the stream in its lower reaches up to the vicinity of its confluence with Red Dog Creek, with a few spawners passing further upstream (Table IV-8, Fig. IV-9). Grayling have been found in good numbers throughout the stream. Chum salmon are known to spawn as far upstream as Dudd Creek, but have not been found above this point. Benthic organisms in Ikalukrok Creek downstream of Red Dog Creek have shown both a reduction in diversity and numbers resulting from the influence of Red Dog Creek.

It is not known whether Red Dog Creek actually causes a partial chemical barrier to char moving up Ikalukrok Creek. However, the fact that other biological responses have been detected (benthic invertebrates), and that char are uncommon near Red Dog Creek while grayling are present, may indicate a greater sensitivity by char and possible avoidance of the area influenced by the creek. The possible differential avoidance of the affected area by these two fish species may in part be due to migration timing (i.e., grayling migrate during spring high water flow when lower metal concentrations are found; char migrate during summer low flow when higher metal concentrations exist). Zinc is known to cause avoidance by salmonid fish at concentrations of 0.054 mg/ℓ (Salmo salar) (Sprague et al., 1965) and 0.0056 mg/ℓ (S. gairdneri) (Clarke, 1974). Avoidance reactions to other metals are not well known.

Dudd Creek is a tributary to Ikalukrok Creek and supports both Arctic char and Arctic grayling in its lower reaches (Dames & Moore, 1983a). This stream provides spawning habitat for char which were enumerated in 1983 by ADF&G (Table IV-8). The 16 adult char counted made up about one to two percent of the known spawning population in the Wulik drainage.

Tutak Creek enters the Wulik River approximately 5 km (3 mi) downstream of the mouth of Ikalukrok Creek. This stream supports populations of slimy sculpin, Arctic grayling and juvenile Arctic char (E.V.S. Consultants, 1983). Char spawning was observed by De Cicco (in press) to occur in locations indicated on Figure IV-9.

Metals in fish tissues from the entire project area were investigated. It was found that cadmium, zinc and copper were elevated in fish captured in the Wulik River drainage. The extent of elevation was related to proximity to Red Dog Creek and probable duration of exposure to that creek over the summer. Other metals examined did not demonstrate elevated levels in fish tissues, and fish from other drainages did not exhibit elevated metals levels. Guidelines for human consumption have not been established for any of the three metals which showed accumulation in fish flesh.

Accumulation of metals in fish tissues is a direct result of metals being absorbed more rapidly than they can be excreted. The rate of accumulation is dependent on the ambient level of biologically available metals. These levels vary with proximity to the source of metals, other water quality characteristics, season and the particular metals and fish species under consideration. Metals found to be elevated in Wulik River fish (cadmium, zinc and copper) do not accumulate in fish through the food web, but instead enter fish in a free ionic state, primarily by passing directly across gill membranes. Apparently, conditions required for the accumulation of metals other than cadmium, zinc and copper do not occur because the excretion rates of fish species involved do not allow accumulation, the metals are not biologically available, or a combination of these two reasons.

Marine Biology

Much of the coastline from Mapsorak Lagoon in the north to Kotlik Lagoon in the south is characterized by a series of open or closed lagoons fronted by barrier beaches. These lagoons tend to be larger in areas where the land slopes gently to the Chukchi Sea (such as at Kivalina and Imikruk Lagoons), and smaller in areas of steep slope (such as at Kavrorak and Tugak Lagoons at the base of the Siaktak Hills). Four rivers (the Singoalik, Kivalina, Wulik and Omikviorok Rivers) enter the Chukchi Sea through lagoons in the study area.

The 15 m (50 ft) depth contour extends approximately 8 km (5 mi) offshore at the southern end of the study area, and approximately 6.4 km (4 mi) offshore in the north near Asikpak Lagoon. The sea floor in the project area is predominantly muds and sands with a mixture of gravel and angular rocks. In general, sands predominate in shallow areas less than 5 m (16 ft) deep, while gravel, angular rock and boulders overlain by finer sands and mud are found in deeper 15 m (50 ft) areas. Attached macroscopic algae are scarce in the area.

Marine Invertebrates

During the open water period in 1982, infaunal* communities were sampled along five transects in the study area (Fig. IV-10) (Dames & Moore, 1983a). In late July and late August, the infaunal community was numerically dominated by polychaetes (segmented worms), followed by crustaceans (amphipods and cumaceans), nematodes (roundworms), tunicates (sea squirts), bivalves (clams) and ophiuroides (brittle stars). The distribution and numerical densities of taxa varied over the study area, but certain patterns were apparent. In general, polychaete species tended to dominate both shallow (5 m [16 ft]) and deeper water (15 m [50 ft]) areas. Cumaceans, nematodes and tunicates occurred primarily in shallow water depths, while ophiuroids and bivalves tended to occur in deeper water. Amphipods were collected at both shallow and deeper depths.

Numerical densities throughout the study area ranged from 267 organisms/m^2 (11 ft^2) to over 24,000 organisms/m^2 (11 ft^2). In general, the number of species and organisms per square meter increased with increasing depth throughout the area. This pattern was probably due to differences in sea floor disturbance and sediment type between shallow and deep water stations.

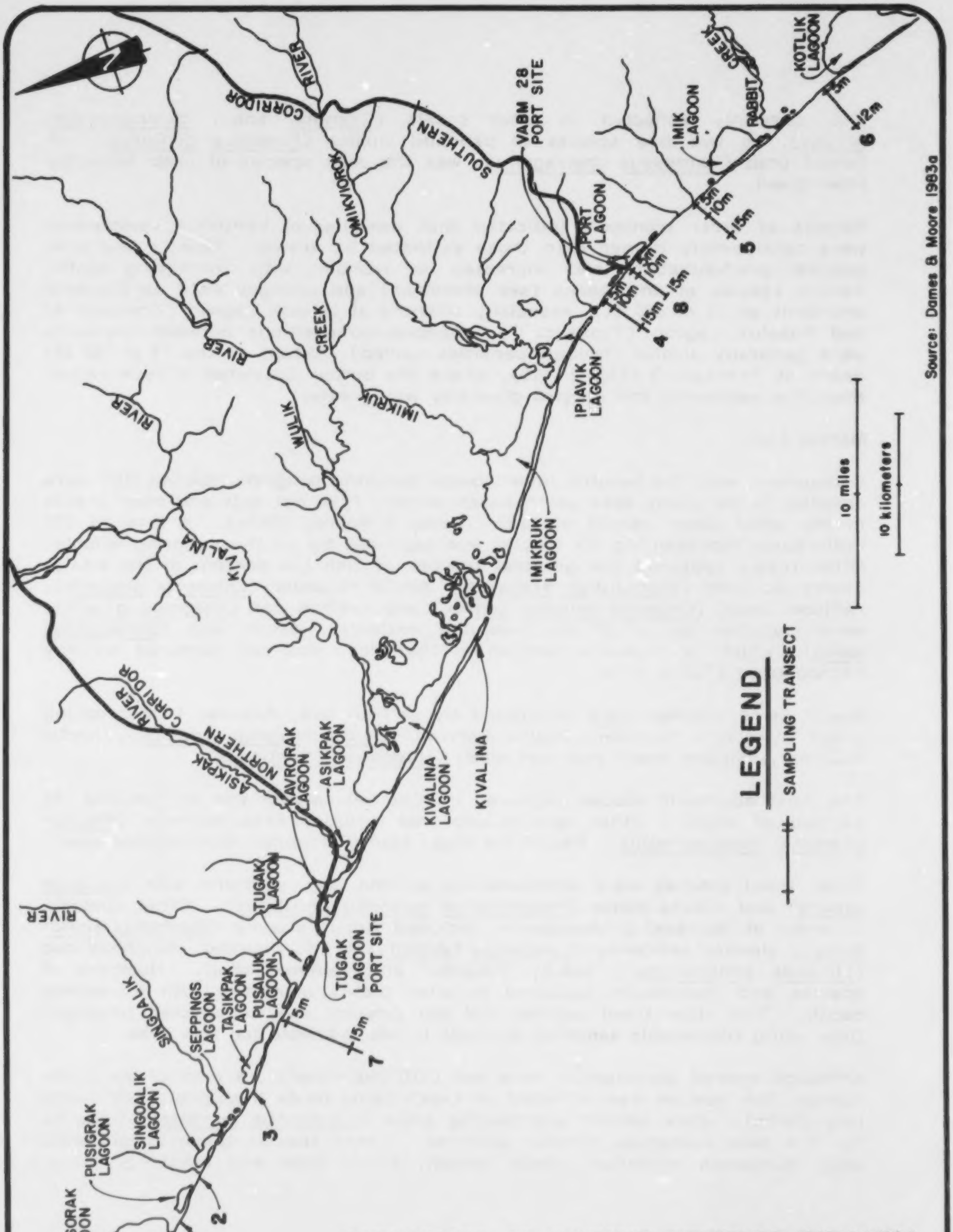
Epibenthic* invertebrates in the study area were also sampled by Dames & Moore (1983a). Dominant organisms captured in epibenthic sled tows were gammarid amphipod crustaceans. Mysids (opposum shrimp) and crangonid shrimp also comprised a large portion of the catch. Gammarid amphipods were abundant at all depths sampled, while mysids were most abundant between 0 and 5 m (16 ft). Crangonid and pandalid shrimp were collected in large numbers between 10 and 15 m (33 and 50 ft.) depth. Brittle stars were locally abundant at deeper stations where mud and silt sediments predominated.

Species diversity of epibenthic sled catches was generally high throughout the study area and tended to increase with increasing depth. The number of species as well as numerical abundance also increased with increasing depth. The lowest diversity occurred at Transect 8 where the gammarid amphipod Monoculodes sp. made up over 89 percent of the organisms collected (Fig. IV-10).

Otter trawl catches were dominated by seastars, particularly the species Asterias amurensis. Other common seastar species were Lethasterias nanimensis, Leptasterias sp. and Crossaster papposus. Crangonid shrimp were

---

* Defined in Glossary.


SOUTHERN CORRIDOR
RIVER
VABM 28 PORT SITE
OMIKVIOROK
RABBIT CREEK
KOTLIK LAGOON
IMIK LAGOON
PORT LAGOON
5m
10m
15m
3m
12m
6
5
4
8
IPIAVIK LAGOON
WULIK
CREEK
IMIKRUK
RIVER
RIVER
IMIKRUK LAGOON
KIVALINA
KIVALINA
KIVALINA LAGOON
LEGEND
SAMPLING TRANSECT
10 miles
10 kilometers
ASIKPAK
NORTHERN
RIVER CORRIDOR
KAVRORAK LAGOON
ASIKPAK LAGOON
TUGAK LAGOON
TUGAK LAGOON PORT SITE
PUSAILUK LAGOON
TASIKPAK LAGOON
SEPPINGS LAGOON
SINGOALIK
RIVER
SINGOALIK LAGOON
PUSIGRAK LAGOON
MAPSORAK LAGOON
5m
15m
1
2
3
7

Source: Dames & Moore 1983a

FIGURE IV-10 MARINE BENTHIC INFAUNA SAMPLING STATIONS

also commonly collected in otter trawls (Crangon spp., Sclerocrangon boreas), as was one species of pandalid shrimp (Pandalus goniurus). A helmet crab (Telmessus cheiragonus) was the only species of crab taken by otter trawl.

Results of diver transects indicated that densities of benthic invertebrates were considerably higher than those estimated by trawls. Seastar and crab species predominated, and increased in number with increasing depth. Sessile species of anthozoans (sea anemones) and sponges were particularly abundant at 15 m (50 ft), especially offshore at Ipiavik Lagoon (Transect 4) and Pusaluk Lagoon (Transect 7). Species compositions between transects were generally similar (though densities varied), except at the 15 m (50 ft) depth at Transect 7 (Fig. IV-10), where the bottom consisted of rock rather than fine sediments and species diversity was greater.

Marine Fish

Concurrent with the benthic invertebrate sampling program, marine fish were sampled in the study area using beach seines, fyke net sets and otter trawls in the open water period of 1982 (Dames & Moore, 1983a). A total of 626 individuals representing 20 species was captured by all the sampling efforts. Otter trawls captured the greatest number of fish (74 percent of the total). Starry flounder (Platichthys stellatus), Arctic flounder (Liopsetta glacialis), rainbow smelt (Osmerus mordax dentex) and saffron cod (Eleginus gracilis) were captured by all of the sampling methods. Arctic cod (Boreogadus saida), which is probably common in the area, was not captured by any method used (Table IV-9).

Beach seine catches were dominated by saffron cod, followed in decreasing order by starry flounder, Pacific herring (Clupea harengus pallasi), Arctic flounder, rainbow smelt and surf smelt (Hypomesus pretiosus).

The most abundant species captured in fyke net catches was saffron cod (65 percent of total). Other species captured included Atka mackerel (Pleurogrammus monopterygius), Pacific herring, starry flounder and rainbow smelt.

Otter trawl catches were dominated by saffron cod, yellowfin sole (Limanda aspera) and Alaska plaice (Pleuronectes quadrituberculatus). Other species, in order of decreasing abundance, included Arctic shanny (Stichaeus punctatus , slender eelblenny (Lumpenus fabricii), Arctic flounder, longhead dab (Limanda proboscidea), starry flounder and rainbow smelt. Numbers of species and individuals captured in otter trawls increased with increasing depth. The otter trawl catches did not present any unexpected findings. Data using comparable sampling methods is not available for this area.

Although overall abundances were low (110 individuals), a total of six anadromous fish species was collected in beach seine hauls throughout the sampling period. Pink salmon and Bering cisco (Coregonus laurettae) were by far the most numerous species collected. Other species taken infrequently were humpback whitefish, chum salmon, Arctic char and Arctic grayling.

Table IV-9

NUMBERS AND PERCENT OCCURRENCE OF MARINE FISH SPECIES COLLECTED DURING SUMMER 1982 BY VARIOUS GEAR TYPES

Species	Gear Type					
	Beach Seine		Fyke Net		Otter Trawl	
	No.	% of Total	No.	% of Total	No.	% of Total
Starry flounder - *Platichthys stellatus*	7	15.2	7	5.9	14	3.0
Arctic flounder - *Liopsetta glacialis*	2	4.4	1	0.8	17	3.7
Yellowfin sole - *Limanda aspera*			1	0.8	94	20.4
Longhead dab - *Limanda proboscidea*					16	3.5
Alaska plaice - *Pleuronectes quadrituberculatus*					87	18.8
Pacific sand lance - *Ammodytes hexapterus*					3	0.7
Rainbow smelt - *Osmerus mordax dentex*	2	4.4	4	3.4	10	2.2
Pacific herring - *Clupea harengus pallasi*	5	10.8	8	6.8		
Saffron cod - *Eleginus gracilis*	24	52.2	77	65.3	143	30.9
Tubenose poacher - *Pallasina barbata aix*					11	2.4
Sturgeon poacher - *Agonus acipenserinus*					9	1.9
Atka mackerel - *Pleurogrammus monopterygius*			19	16.1	9	1.9
Fourhorn sculpin - *Myoxocephalus quadricornis*					6	1.4
Slender eelblenny - *Lumpenus fabricii*					20	4.3
Arctic shanny - *Stichaeus punctatus*					21	4.5
Bering poacher - *Occella dodecaedron*					1	0.2
Surf smelt - *Hypomesus pretiosus*	2	4.4				
Larval smelt - Family Osmeridae	4	8.7				
Ringtail snailfish - *Liparis rutteri*					1	0.2
Nine-spine stickleback - *Pungitius pungitius*			1	0.8		
	46	100.0%	118	100.0%	462	100.0%

Source: Dames & Moore, 1983a

Beach seines were used to sample several lagoons in the study area (Dames & Moore, 1983a). At the time of sampling, Ipiavik Lagoon was the only water body open to the sea. This lagoon contained three marine species (Arctic flounder, starry flounder and Pacific herring) and the fry of two anadromous species (humpback whitefish and pink salmon). Kavrorak Lagoon was also sampled by beach seine and contained landlocked Arctic char. Both lagoons also contained nine-spine stickleback, a typical estuarine species.

Marine Birds and Mammals

Marine birds in the vicinity of the project area would generally be associated with the colonies at Cape Thompson. In the early 1960's these cliffs supported over 400,000 seabirds (Swartz, 1966), although numbers have steadily declined since then (Springer and Roseneau, 1977, 1982). Marine birds generally forage well offshore to the south of Cape Thompson and would not normally be found in significant numbers nearshore in the project area.

Marine mammals of the Chukchi Sea have received considerable attention because of their importance to Native subsistence lifestyles as well as their ecological significance (Johnson et al., 1966; Burns and Harbo, 1972; Burns and Eley, 1978). Depending upon the time of year and ice conditions, the eastern Chukchi Sea/Kotzebue Sound region supports four species of seals: the ringed seal (Phoca hispida), spotted seal (P. largha), bearded seal (Erignathus barbatus) and ribbon seal (P. fasciata). Of these, only the ringed, spotted and bearded seals may be considered common.

The ringed seal is a winter inhibitant of Kotzebue Sound, being most common in the eastern sound where fast ice predominates. It is less common along the coast near Kivalina which is dominated by a persistent polynya*. Pupping occurs primarily in the limited fast ice along the shore during late March/early April (Burns, personal communication).

The ringed seal is replaced by the spotted seal during the ice-free summer period. Bearded seals may be found during the periods of ice formation and breakup. The northern fur seal (Callorhinus ursinus) has occasionally been reported in the region.

Four species of cetaceans (whales and porpoises) are found in the region. These are the belukha or white whale (Delphinapterus leucas), Gray whale (Eschrichtius robustus), bowhead whale (Balaena mysticetus) and the harbor porpoise (Phocoena phocoena). Only the belukha and Gray whales can be considered common. Gray and bowhead whales are classified as endangered species under the federal Endangered Species Act. Harbor porpoise are common, but occur in low numbers.

A large group of belukhas numbering over 10,000 winters in the Bering Sea. While a majority of these animals moves north in the spring through the Bering Straits, past Point Hope and into the Beaufort Sea, a group numbering between 500 and 1,800 enters eastern Kotzebue Sound about mid to late June. Most of these individuals stay in the area between Kotzebue and Eschscholtz Bay, but others may be found throughout the sound. Some calving occurs. In early to mid July many of the belukhas apparently move out of the sound, possibly to and past Point Hope (Frost, personal communication).

---

* Defined in Glossary.

From their wintering grounds in the western and central Bering Sea, the western Arctic population of bowhead whales usually begins its northward (spring) migration in early April. After passing through the Bering Strait and into the Chukchi Sea, generally west of Big Diomede Island, the whales follow ice leads seaward of landfast ice. These leads usually bring them across outer Kotzebue Sound in a northeasterly direction to the vicinity of Cape Thompson (McVey, personal communication). Some whales move through the polynya that forms west of the project area between Kivalina and Point Hope (Braham and Krogman, 1977; Braham et al., 1980). During the past three years, National Marine Fisheries Service (NMFS) data show very few bowheads east of approximately 167° W longitude, well away from the project area (Johnson, personal communication). From Cape Thompson open leads are again followed past Cape Lisburne to Point Barrow (Braham et al., 1980; Rugh and Cubbage, 1980) and northeastward toward Banks Island in the Canadian Beaufort Sea where the majority of the whales arrive by mid-June to spend the summer. The fall migration toward the Bering Strait, after passing Point Barrow, is believed to occur in the western Chukchi Sea well to the west of the project area (Braham and Krogman, 1977; Cowles, 1981).

Gray whales migrating north from their wintering grounds enter the Bering Sea in April or May with many moving through the Bering Strait into the Chukchi Sea by June. During the summer most of the population concentrates in shallow waters around St. Lawrence Island north to the Chukchi Sea (McVey, personal communication). Sightings suggest that they occur in low densities in nearshore areas in Kotzebue Sound and north of 69°N latitude (Marquette and Braham, 1982). Southward migrations appear to be through the western Chukchi Sea.

Walrus (Odobenus rosemarus) are also found in the area during the ice-free season, but they are uncommon or only occasional visitors to the area.

Polar bears (Ursus maritimus) occur along the coast of the project area during the winter. Their numbers vary greatly between years depending upon the timing and direction of ice movements. In most years very few bears are normally found between Kivalina and Point Hope, but when northwest winds drive the ice southeast along this coast, polar bear numbers can increase significantly.

Threatened or Endangered Species

Two species of marine mammals are listed as endangered: the bowhead and Gray whales. These species are primarily migrants through the project area during their northern movements in the spring, normally staying well to the west in the Chukchi Sea during their southward migrations in the fall. Additional information may be found in the preceding section on marine birds and mammals, and in Appendix 3 (Endangered Species Biological Assessment).

Physical and Chemical Oceanography

The coastline in the study area between latitudes 67°39'N and 68°00'N, has a relatively straight northwest to southeast orientation with a land surface consisting of a gently sloping plain. This plain continues underwater so that the 15 m (50 ft) depth contour lies nearly 8 km (5 mi) offshore in most locations. The area is also characterized by a series of open or closed lagoons fronted by barrier beaches or islands.

Currents/Circulation

Oceanographic conditions in the southeastern Chukchi Sea were shown by Barnes and Thompson (1938) to be primarily influenced by the northward flow of water through the Bering Strait. Studies conducted by Fleming and Heggarty (1966) showed that currents along the coastline are strongest near shore, generally to the north or northwest, and roughly equal in velocity at 5 and 20 m (16 and 66 ft) depths. Current speeds range from approximately 0.5 to 1.0 m/s (1 to 2 knots) through summer. Wind and winter ice cover movement can retard or reverse surface currents. Fleming and Heggarty (1966) found that water residence time in the Chukchi Sea is short. An average of 15 days is required for water to move from the Bering Strait to Point Hope.

Diurnal tides occur in the Chukchi Sea, but the estimated tidal range of 0.3 to 0.8 m (1.0 to 2.6 ft) is quite small. Published tidal data for Kiwalik (southern Kotzebue Sound) shows a mean tidal range of 0.6 m (2.0 ft).

Wind and Wave Climate

Wind and wave conditions have a significant effect on sediment movements along the coast. Due to a lack of consistent long-term data for the study area, it is difficult to determine typical wind velocity and wave height values and therefore make predictions about the longshore transport of sediments.

Generalized data indicate that prevailing summer (June to October) winds are from the northwest to west and range from 4 to 5 m/s (8 to 10 knots). These winds occur about 50 percent of the time. The next most prevalent wind direction is from the south to southeast and occurs about 25 percent of the time. Major storms with winds up to 35 m/s (70 knots) generally come from this direction.

Wave height is directly related to wind fetch and wind duration. A 2.6 m (8.5 ft) wave could be generated in one hour by a 35 m/s (70 knot) wind blowing over a fetch of 320 km (200 mi), while 3.3 m (11 ft) waves could be expected from a 25 m/s (50 knot) wind blowing for 4 hours. Breaker height is dependent on wave height, wave periodicity and the slope of the beach. For example, a 3.3 m (11 ft) wave could run up a 0.028 slope beach (as found at the port site) to a height of 3.6 m (12 ft). Storm surges may raise the sea level by as much as 3 m (10 ft). Waves under these conditions could cause significant erosion and breaching of coastal barrier beaches found in the project area.

Wind and wave statistics were estimated for the port sites using Kotzebue records of wind speeds and directions. These statistics were developed for the approximately 100 shipping days from the end of June until early October (Table IV-10).

Table IV-10

PERCENT OCCURRENCE OF HIGH WINDS AND ASSOCIATED STORM WAVES (NOT INCLUDING SWELL) AT THE PORT SITES

Event	Percent Occurrence
Wind Speed	
6.5 to 8.5 m/s (13 to 17 knots)	16.0
9.0 to 11.0 m/s (18 to 22 knots)	9.5
11.5 to 13.5 m/s (23 to 27 knots)	2.5
14.0 to 16.0 m/s (28 to 32 knots)	0.5
Storm Wave Height	
>1.2 m (4 ft) and <1.5 m (5 ft)	7.2
>1.5 m (5 ft) and <1.8 m (6 ft)	4.4
>1.8 m (6 ft) and <2.1 m (7 ft)	2.0
>2.1 m (7 ft)	3.0

Source: National Climatic Center Records, 1973 to 1982

Wave statistics developed for the Northern Pacific have shown that the magnitude and frequency of swell waves (generated by distant storm winds) are approximately the same as local storm waves. The significant storm wave percent occurrence (Table IV-10) should, therefore, be doubled to account for swell waves generated by storms offshore in the Chukchi Sea. Thus, lightering operations and loading operations on unstable platforms would be difficult or dangerous at wind speeds over 11 m/s (22 knots) (three percent of the time), and during waves over 1.5 m (5 ft) (18.8 percent of the time). These combined adverse conditions would occur approximately 20 to 22 percent of the time at the port sites.

Coastal Geologic Processes

Studies by Moore (1966) and Hopkins (1977) indicate that long-term net sediment transport is in a southeasterly direction, though average annual sediment movement takes place perpendicularly to the shoreline. Huge quantities of beach sand (on the order of millions of cubic meters) can be washed out in a single storm and deposited as a bar near the wave break point. For example, on August 9, 1960, Ogotoruk Beach, located 66 km (41 mi) northwest of Kivalina, was lowered 1.0 m (3.3 ft) by waves 15 m (50 ft) long and 1.4 m (4.6 ft) high (Moore, 1966). Sediments subsequently are restored to beaches by more normal sea conditions.

In addition to the huge movement of beach sediment perpendicular to shore, a small component of net sediment movement is directed southeasterly between Point Hope and Cape Krusenstern. Sediment movement can thus be pictured as a zig-zag pattern with a small but important quantity displaced southward in an average year. Over a long period, Moore (1966) estimated that about 22,000 m^3 (28,780 yd^3) of sediment are annually transported along the shore to Sheshalik Spit, 43 km (27 mi) east-southeast of Cape Krusenstern. Quantities of sediment moved vary considerably each year. Woodward-Clyde Consultants (1983) calculated that 82,580 m^3 (108,000 yd^3) of sediment were transported southeast along the coast each year. In some years a reverse movement of sediment may also occur.

Hopkins (1977) calculated that beach erosion between Kivalina and Cape Krusenstern is of the same order of magnitude as the quantity of material deposited in the Cape Krusenstern beach ridge complex. Apparently rivers and streams (such as the Singoalik and Wulik Rivers and Agagrak, Rabbit and Kilikmak Creeks) as well as submerged sand bars serve as sediment sources. Most sediment transport probably occurs in the summer months when winds are predominantly from the west and northwest. Sediment displaced in the winter by ice action is probably insignificant compared to wind-driven sediment transport (Moore, 1966).

Marine Water Quality

The Chukchi Sea typically has relatively warm, low salinity water present near shore. Following ice breakup in late June, freshwater influence near shore is high due to melting ice and high stream runoff. Incoming fresh water dilutes nearshore surface waters in summer so that salinities range from 22 to 29 parts per thousand (ppt). Colder, deeper water and water farther offshore typically has salinities ranging from 31 to 33 ppt. There is a trend for salinity to increase in surface waters from late June through late August. Seawater temperatures along the coast are generally quite warm (11° to 14°C [52° to 57°F]). No significant cooling or warming trend occurs over the summer, nor are seawater temperatures significantly warmer (greater than 0.5°C difference) nearshore compared to offshore.

Temperature and salinity measurements were taken in the study area during the open water period of 1982 (Dames & Moore, 1983a). In general, temperature and salinity profiles showed decreasing temperature and increasing salinity values with depth. At deeper stations, the surface water layer was well mixed to a depth of 6 to 8 m (20 to 26 ft), and a sharp thermocline* was present between 8 and 10 m (26 to 33 ft). A thermocline occurs where there is a rapid decrease in water temperature with depth, in this case a 2.1°C (3.8°F) difference in 2 m (6.6 ft). At shallower, more nearshore stations, a less distinct thermocline (1.1°C [2.0°F] temperature change in 2 m [6.6 ft]) occurred between 4 and 8 m (13 and 26 ft) of depth. Salinity varied from 25 ppt at the surface to 31 ppt at a depth of 12 m (40 ft). Lagoons in the study area are highly variable in physical and chemical parameters. Closed lagoons tend to be mostly freshwater with a slight brackish nature near their ocean shorelines. Open lagoons are normally more saline near the opening and fresher near the creek and river mouths.

Ice Conditions

Sea ice generally begins to form on the coast in early October, but periodic high winds and waves may delay formation of solid cover until January. Sea ice normally reaches a thickness of 2 to 3 m (6.6 to 9.8 ft) during the course of the winter, but can reach greater depths when it is piled up due to storm driven currents. Melt pools and cracks begin to form in May and June, and the ice cover usually disappears by early July. The edge of landfast ice is usually 3 to 8 km (2 to 5 mi) offshore in an average winter. The edge of landfast ice usually approximates the 9.2 m (30 ft) depth contour where it can contact the bottom when it is piled into ridges. Landfast ice, though stable through winter, is subject to movement during break-up.

Pack ice generally retreats north of Point Hope in August, September and October. During late winter and spring, pack ice and landfast ice are usually separated by a shear zone approximately 64 to 80 km (40 to 50 mi) wide with open leads present.

Shore ice pile-up has been observed on the Chukchi and Beaufort Sea coasts to heights of over 9.2 m (30 ft) up to 9.2 m (30 ft) onto the beach. The same pile-up heights could occur on offshore structures. Ice run-up has been observed also when relatively thin sheets of ice (0.6 to 1.5 m [2 to 5 ft] thick) run up beaches as far as 92 m (300 ft) from the water's edge. Ice run-up reached heights of 9.2 m (30 ft) above the beach water line.

Meteorology and Air Quality

Meteorology

When the Chukchi Sea is generally ice-free (late June through early October), the coast of the project area is dominated by a polar maritime climate, with cooler air temperatures, more frequent fog and clouds, and stronger westerly winds compared to the inland transportation corridors and the De Long Mountains. The summer inland climate is more continental with greater sunshine, greater daily temperature swings and variable winds. In winter months, climate is generally similar on the seacoast and inland, with some differences in wind, precipitation and temperature depending on proximity to the De Long Mountains. Mountain locations would have more variable winds, greater precipitation and warmer temperatures compared to coastal locations.

---

* Defined in Glossary.

Meteorological data applicable to the Red Dog project area were available for Kotzebue, Point Hope and Cape Lisburne from the National Climatic Center. Comprehensive meteorological records were also available for a two-year period from Ogotoruk Valley (Project Chariot) at Cape Thompson, 65 km (40 mi) northwest of Kivalina. A compilation of climatological data for the coastal regions was available in Brower et al. (1977).

Near the seacoast, typical summer temperatures range from 4° to 13°C (39° to 55°F) and winter temperatures range from -26° to -15°C (-15° to 5°F). Seacoast temperature extremes are -47°C (-53°F) in winter and 29°C (84°F) in summer. In the De Long Mountain foothills, summer temperatures typically fluctuate between 2° and 18°C (36° and 64°F), with extreme high temperatures near 32°C (90°F). The winter inversion layer usually lies below the higher hills and ridges of the De Long Mountains, so extreme winter low temperatures occur less frequently in the mountains.

Mean monthly cloudiness over the seacoast ranges from 50 to 80 percent, with most clear days occurring in winter. Fog occurs about 10 percent of the time on the coast. The sun is continuously above the horizon for approximately seven weeks centered around June 22 (the summer solstice). Due to orographic* shading by the De Long Mountains, the sun sets for a few hours in Red Dog Valley, even in June. The sun is continuously below the horizon for approximately four weeks centered around December 22 (the winter solstice). A minimum of 4 to 5 hours of twilight adequate for outdoor activities occurs during this time.

Mean annual precipitation on the seacoast and coastal lowland is approximately 25 cm (10 in). Orographic effects cause precipitation to increase to 38 cm (15 in) on the coastal upland, and precipitation ranges from 51 to 76 cm (20 to 30 in) in the De Long Mountains. Nearly half of the mean annual precipitation occurs as rain during the three months of July through September. August is the wettest month of the year, receiving one-quarter of the annual precipitation. Mean annual evaporation from lakes and wetlands in Arctic conditions found in the foothills of the De Long Mountains varies from 15 to 23 cm (6 to 9 in). Most of this evaporation occurs from May through August.

Snowfall has been recorded every month of the year, but consistent snow cover generally occurs only from the middle of October to the middle of May. Maximum snow depths have reached 1.2 m (4 ft), but typical late winter depths are 0.6 m (2 ft). Considerable blowing and drifting of snow occurs in coastal locations and on exposed peaks and ridges. In these windy areas, strong east to northeast winds create bare ground over 30 to 40 percent of the area. Snowdrifts 1.8 to 3.0 m (6 to 10 ft) deep accumulate in depressions and in the lee of banks.

---

* Defined in Glossary.

There are marked seasonal differences in wind regime, particularly on the seacoast. In winter the Arctic Front and associated storm tracks are normally far to the south. The Polar Cold High generates strong north to east winds with the direction depending on local topography. Predominate winds on the seacoast and the coastal upland are easterly, down the Wulik River valley and parallel to the southern edge of the Brooks Range. During winter this direction predominates over 60 percent of the time, with mean annual wind speeds for all directions of 5 to 6 m/s (10 to 12 knots). When low pressure centers are present in the Chukchi Sea, strong southeast winds blow parallel to the coast.

Summer winds in the coastal areas are much more variable than during winter, and speeds decrease to a mean of 4 to 5 m/s (8 to 10 knots). West to northwest winds occur approximately 50 percent of the time, while east to northeast winds occur 35 percent of the time. Most of the west and east winds result from a sea breeze circulation that develops in late spring after break-up. The strongest summer winds (south to southeast) are associated with low pressure centers in the Chukchi Sea and may have maximum wind speeds of 35 m/s (70 knots).

In the vicinity of the De Long Mountain foothills and in Red Dog Valley, local topography strongly influences wind direction and velocity. Predominate winter winds (north to northeast) are channeled by the valleys of the Wulik River, Ikalukrok Creek, and the North and South Forks of Red Dog Creek. Mean annual wind speeds average 2.5 to 3 m/s (5 to 6 knots) in Red Dog Valley. Near calm conditions can be expected 20 percent of the time on the valley floor due to local cold air pooling.

Summer winds in the De Long Mountain foothills are controlled by local valley circulation patterns. Up-slope winds occur during the day, and light downslope or down-valley winds typically occur at night. Occasional strong southerly winds may occur in association with storm systems approaching from the west.

Air Quality

There are no significant air pollutant sources in northwestern Alaska. Therefore, background levels in the Red Dog project area are assumed to be negligible. From measurements taken in similar remote areas, air pollutant concentrations are probably less than follows: particulates 30 $\mu g/m^3$, nitrogen dioxides 10 $\mu g/m^3$, sulfur dioxide 3 $\mu g/m^3$, ozone 60 $\mu g/m^3$ and carbon monoxide 500 $\mu g/m^3$.

Natural particulate levels are probably high during strong winds due to lack of soil-protecting vegetation on hilltops and ridge crests. Observations at Cape Thompson showed that strong winter winds created large bare areas which generated surface dust deposits on snow cover downwind. High concentrations of smoke particulates may also occur as a result of rare summer tundra fires.

Visual Resources

Basic methods used to determine the value of visual resources have been developed by the U.S. Forest Service in its Visual Resources Management (VRM) Program. The visual characteristics of a landscape include visual variety, the number and interest of viewers, and the land's ability to visually change without losing its inherent character. Visual variety has been shown to be a good predictor of viewer preference. The number, interest and location of viewers are also factors used to identify visually important areas.

For any particular area, visual variety classes are determined based on the relative value of the surrounding area. For example, lands with visual variety typical of the region are classified as "common" or Class B lands. Areas with special patterns of vegetation, water or landforms are considered "distinctive" or Class A lands. Areas with very little variety or interest are considered "minimal" or Class C lands.

The Red Dog project area, including the De Long Mountains, the Mulgrave Hills, and the Kivalina and Wulik River basins, is highly scenic relative to the lower 48 states. A majority of the project area is rated variety Class A. Highly rated areas include the shoreline, the larger rivers and adjacent lakes, notable hills, and the more mountainous areas to the north and east. The remainder of the landscape is considered Class B. None of the landscape is considered variety Class C.

The VRM system combines data on the number and interest of viewers to determine a sensitivity rating for any particular area. Because of its remoteness and the limited number of use areas (those being the village of Kivalina and Cape Krusenstern National Monument), the general visual sensitivity of the project area is considered to be low. Cape Krusenstern National Monument is considered an area of high sensitivity based on projections of future use.

The VRM program combines data on visual variety classes with sensitivity ratings to determine Visual Quality Objective (VQO) zones. Five general VQO zones are defined as follows:

- Preservation - No visual changes permitted.
- Retention - Visual changes must blend with the form, line, color and texture of the existing landscape.
- Partial Retention - Visual changes must be subordinate to and borrow visual elements from the natural landscape.
- Modification - Major visual changes are allowed, but changes must borrow from existing visual elements of the landscape.
- Maximum Modification - Major visual changes allowed. Conformity with the natural landscape is not required.

VQO zones defined in the study area are shown on Figure IV-11. The Wulik and Kivalina River basins, and the Mulgrave Hills in Cape Krusenstern National Monument are classified as retention level quality. The remainder of the project area is generally classified as partial retention quality. In general, the project area is high in visual variety but low in visual sensitivity.

Red Dog project components occur in landscapes with varying visual characteristics. The northern transportation corridor passes through areas of both high and moderate visual variety. The southern transportation corridor is located predominantly in an area of moderate visual variety, but is close to viewers in Cape Krusenstern National Monument. The northern transportation corridor passes through retention quality areas, while the southern corridor lies within partial retention areas. The port sites are located in areas of high visual variety and partial retention quality.

Sound

The Red Dog project area is located in a remote region of northwestern Alaska. The closest communities are the small Native villages at Kivalina (located on the coast 32 km [20 mi] northwest of the proposed southern port site), and at Noatak (located 42 km [26 mi] south of Red Dog Valley). Data from similar remote locations indicate that typical natural noise levels usually range from 15 to 45 dB(A), which is considered quiet (see Table V-7 for comparison values). Natural noise levels up to 65 dB(A) may be associated with storms and wildlife. Areas along the coast would have the highest noise level due to strong winds, breaking waves, ice movements, marine mammal cries and bird calls. Maximum natural noise levels along the proposed transportation corridors and in the De Long Mountains would be caused by wind, rain, wildlife and rare thunder.

Noise associated with the Native communities would not be discernable in most of the project area, except that resulting from subsistence hunting activities (use of snowmobiles, outboard motors and float planes). These types of activities typically generate noise levels up to 85 dB(A) at 15 m (50 ft). Noise is presently being generated by temporary mining exploration activities concentrated in the De Long Mountains. Infrequent helicopter and light plane overflights at low altitudes may also occur in the project area. These flights would generate ground level noise up to 90 dB(A).

Cultural Resources

It is generally accepted that the first Asian immigrants to the North American continent crossed the Bering Strait (Beringia), arriving in what is now Alaska in the area of the Seward and Lisburne peninsulas. They then moved eastward, probably north of the Brooks Range, into the Canadian interior and southward east of the Rocky Mountain chain. This movement is generally thought to have occurred toward the close of the Wisconsin glacial advance, perhaps 10,000 to 15,000 years ago, although many scholars have postulated the initial date of immigration at 80,000 to 100,000 years.

The Alaskan link between Asia and the early human sites in the interior, while widely accepted in theory, is not well-documented in fact. Tangible

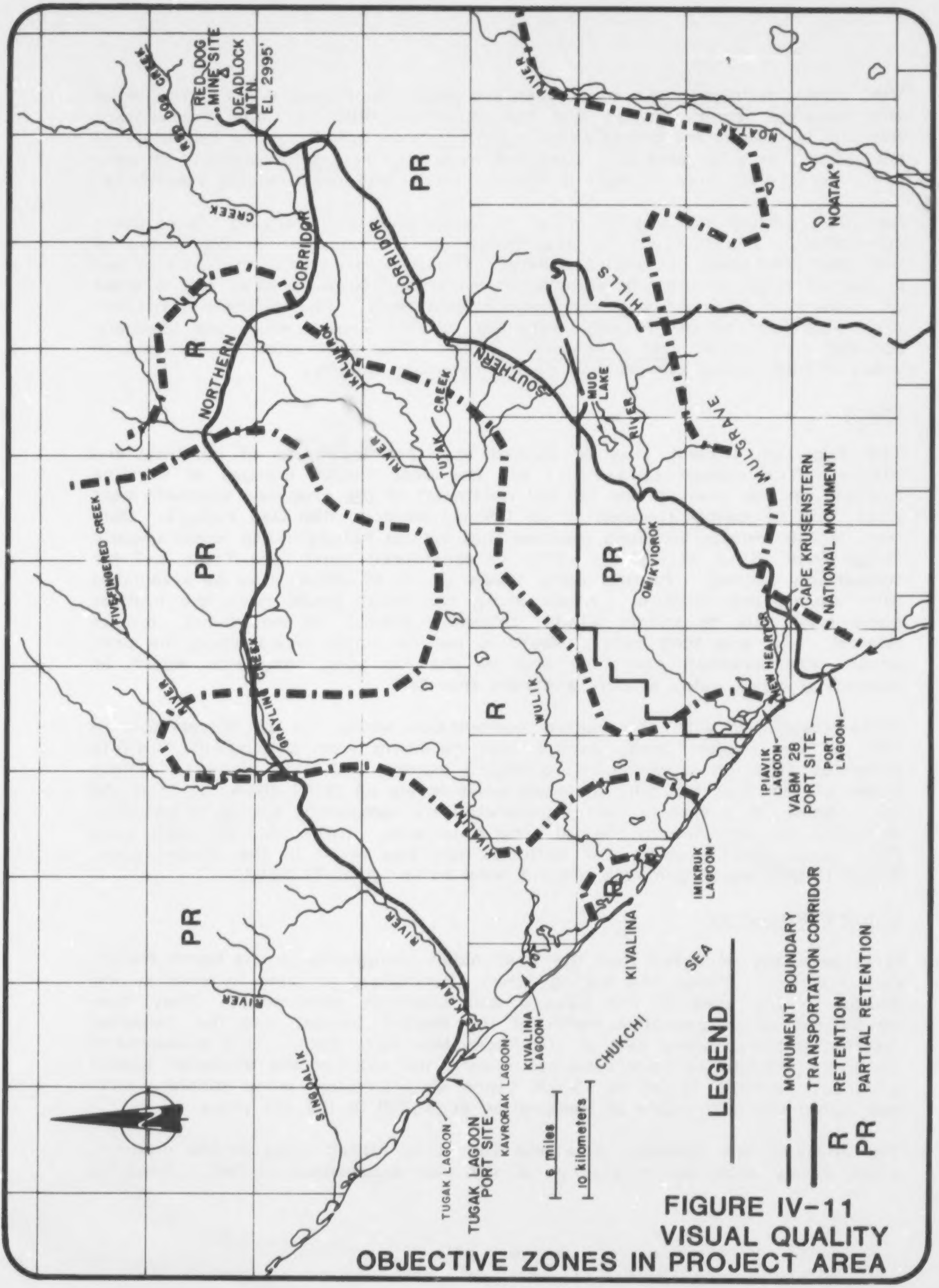

RED DOG MINE SITE
DEADLOCK MTN
EL. 2995'
RED DOG CREEK
CREEK
PR
R
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
IKALUKROK
TUTAK CREEK
RIVER
MUD LAKE
HILLS
NOATAK RIVER
NOATAK
MULGRAVE
OMIKVIOROK RIVER
CAPE KRUSENSTERN NATIONAL MONUMENT
NEW HEART CR.
FIVEFINGERED CREEK
GRAYLING CREEK
WULIK
KIVALINA
KIVALINA RIVER
SINGOALIK RIVER
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
IMIKRUK LAGOON
KIVALINA LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
CHUKCHI SEA
6 miles
10 kilometers
LEGEND
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
R RETENTION
PR PARTIAL RETENTION

FIGURE IV-11
VISUAL QUALITY
OBJECTIVE ZONES IN PROJECT AREA

evidence may have been inundated as ocean levels rose with the melting of the continental ice sheets. If so, those data are likely lost to bottom scouring or strong ocean floor currents in the Bering Strait area. Site evidence may also have been destroyed or disseminated by glacial action or natural forces associated with land elevation changes resulting from glacial retreat. It may also be that evidence of this earliest occupation has not been discovered, or perhaps simply not recognized. It is fair to conclude that if evidence of these first immigrants is to be found, it will likely be discovered in the region where earliest contact was possible. This would include the Red Dog project area.

The earliest prehistorical remains in the vicinity of the Red Dog project area are located on a series of beach ridges at Cape Krusenstern, and form the core of the Cape Krusenstern National Monument and the Cape Krusenstern Archeological District (Fig. 1-1). The latter classification requires management consideration for any archeological resource in the District (there is a presumed eligibility to the National Register of sites for all recorded and unrecorded sites within the Archeological District). The Cape Krusenstern Archeological District encompasses approximately 809,000 ha (2,000,000 ac) and includes most of the proposed transportation corridors.

While the National Monument constitutes only approximately 25 percent of the District, its existence is predicated on the archeological remains in the area that depict every known cultural period in Arctic Alaska. It is the purpose of the Monument to preserve and interpret evidence of prehistorical and historical Native cultures. The easily visible concentration of house and occupied sites in the Monument are often used as a diachronic* model of human life in northwestern Alaska (Giddings 1967; Giddings and Anderson, in press).

Archeological sites located within the Red Dog project area are typical of interior northwestern Alaska. These sites consist of surface scatters, or shallowly buried deposits of lithic materials that were used in making stone artifacts (Hall, 1982a). The localities served as prehistoric flaking stations associated with upland game procurement, though some may have been ephemeral camps. More permanent settlements are known closer to the coast, although the majority of coastal sites within the project area relate to recent periods (Hall, 1982a,b; 1983a).

Four archeological sites are located in the immediate area of the mine. At least a dozen more archeological localities are within a 3 km (1.9 mi) radius of the mine, mill, tailings pond and water storage facilities complex.

There are 13 archeological sites along the southern transportation corridor (Hall 1982a,b; 1983a). Seven of these sites are within the Cape Krusenstern Archeological District, with six of those sites being within Cape Krusenstern National Monument. The other sites are on state selected or tentatively approved lands. There are 23 archeological sites along the northern transportation corridor (Hall 1982a,b; 1983a). None of these sites are within Cape Krusenstern National Monument or the Cape Krusenstern Archeological District. All 23 sites are on state selected or tentatively approved lands.

---

* Defined in Glossary.

Sites related to coastal activities are located at each port site. There is a small eroding cabin at Tugak Lagoon of which little remains (Hall, 1983a). A reindeer herding facility is present on private land at the VABM 28 port site which may provide physical documentation for the historical reindeer herding activity in this area.

The upland hunting sites of the Red Dog project area may reflect seasonal use of the interior during months of resource unavailability at the coast. Similar sites which reflect inland travel from Cape Krusenstern have been noted for the De Long Mountains (Smith, 1982; Hall, 1982a,b; 1983a).

Subsistence

Subsistence is vital to the economic well being and nutrition of most of the region's residents. The extent of its importance is indicated by the findings of a 1978 survey of about one-third of the region's households. Approximately 55 percent of all households estimated they obtained half or more of their food supply by subsistence hunting, fishing and gathering (Table IV-11). This survey found that subsistence dependence was widespread throughout the region, but much more pronounced in the outlying villages, including Kivalina and Noatak, than in Kotzebue. In a region where imported foodstuffs are costly and cash income depressed, the economic importance of the subsistence food supply is evident. Within this general reliance on subsistence, there is a great deal of variation from settlement to settlement, season to season, and year to year in subsistence harvest patterns (Social Research Institute, 1982).

The region encompasses a great diversity of terrestrial, freshwater, marine and wetland habitat types which support many valuable subsistence species. Virtually the entire region and most of its nearshore marine waters fall within the subsistence use area of one or more villages (Fig. IV-12).

Among the most important subsistence food resources are land mammals (caribou, moose), fish (Arctic char, chum salmon, sheefish, whitefish, tomcod, smelt), sea mammals (bearded, ringed and spotted seals; belukha whales) and waterfowl. However, nearly all edible animal species are used to add variety to the customary diet or in times of scarcity. Berries and other wild plant foods are also extensively gathered for consumption.

Most of these subsistence resources (e.g., caribou, Arctic char, salmon, marine mammals, plant foods) are either migratory or highly seasonal; the period of their peak availability is often very brief and localized. Thus, the yearly cycle of subsistence harvest activites for each settlement reflects closely the timing and specific mix of locally available resources. Figures IV-13 and IV-14 show typical annual subsistence activity cycles for Kivalina, Noatak, and other selected community groups in the region. However, it should be stressed that the "typical year" rarely occurs because the pattern of resource availability is so unstable. Adaptation to these uncertain circumstances has produced a highly complex, diverse, and flexible pattern of subsistence activity that continually adapts to harvest opportunities.

Table IV-11

NANA REGION
HOUSEHOLD DEPENDENCY ON SUBSISTENCE HARVEST[1]
PERCENT DISTRIBUTION

	NANA Region	Kivalina	Noatak	Kotzebue	Other Villages[2]
All	7.5	5.6	--	5.6	12.4
Most	24.8	16.7	57.1	14.9	30.1
Half	23.2	38.9	28.6	16.1	27.5
Some	36.1	38.9	14.3	49.1	27.5
None	8.5	--	--	14.3	2.6
TOTAL	100.0	100.0	100.0	100.0	100.0

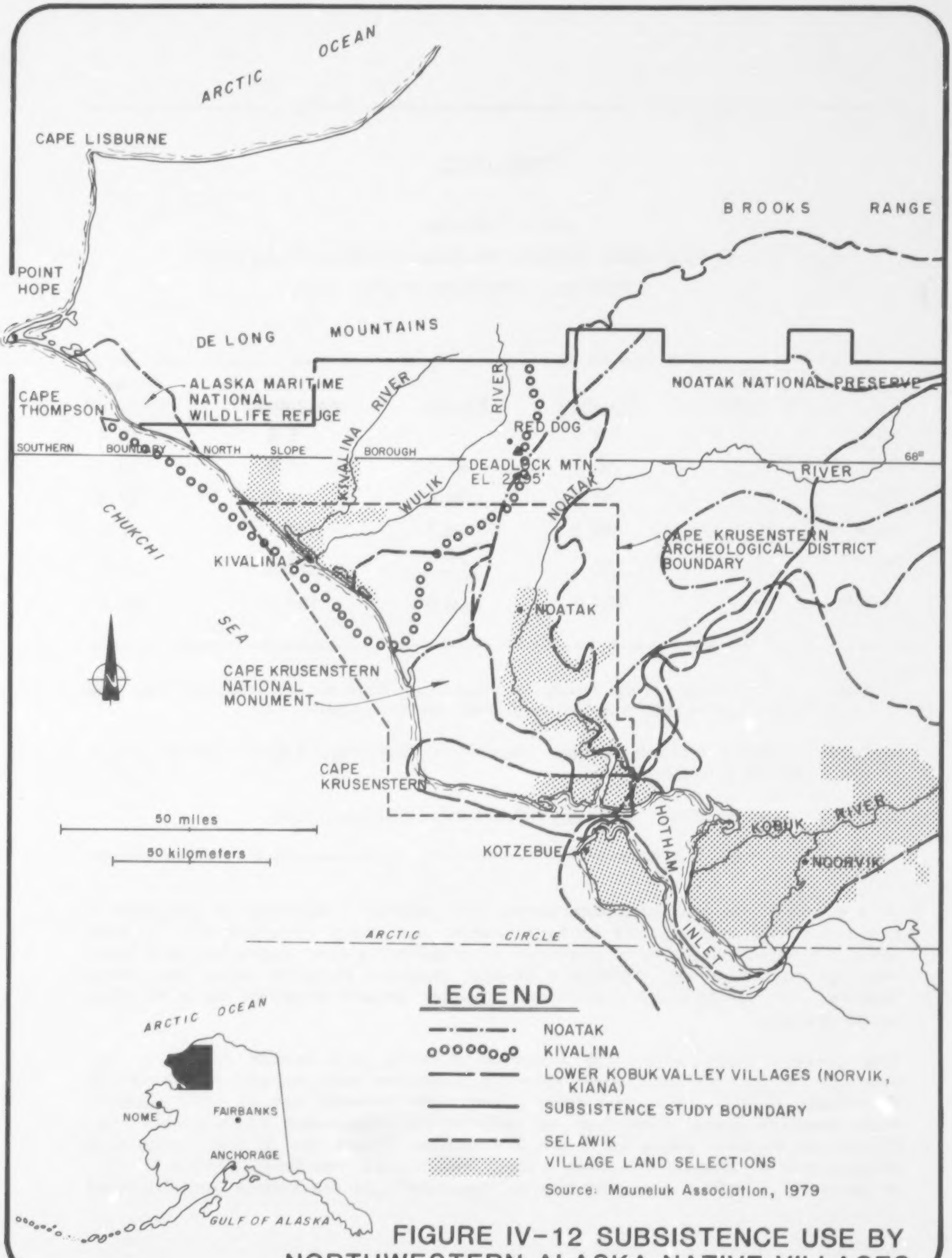
[1] Reply to question: How much of your own food would you say you and your family gathered, hunted or fished for this year?

[2] Other villages include Ambler, Buckland, Deering, Kiana, Kobuk, Noorvik, Selawik and Shungnak.

Source: NANA Regional Strategy, Community Survey, 1978

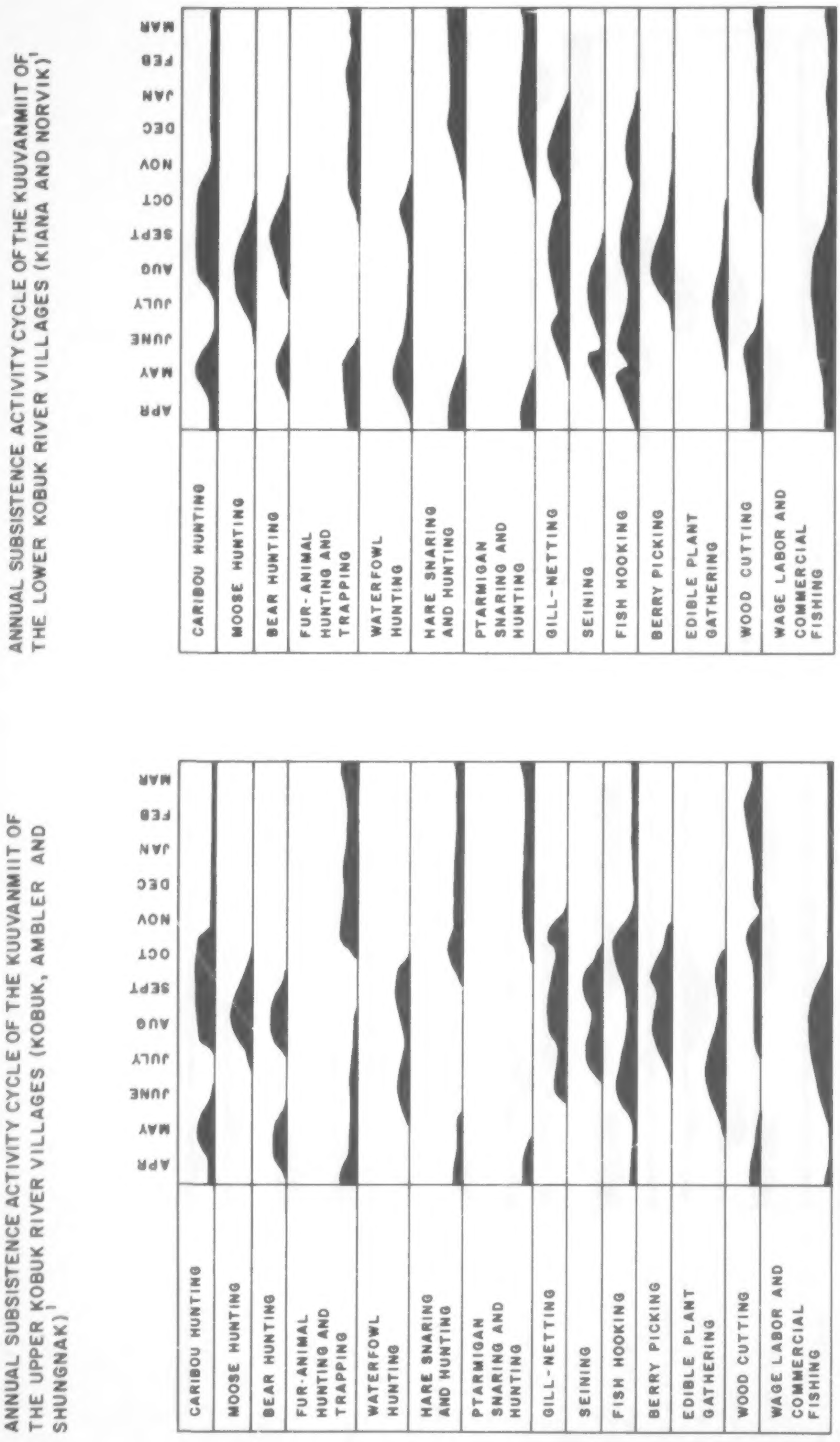
In addition to its economic importance, subsistence is essential in structuring and sustaining the region's cultural values and social organization. It sustains the important cultural practices of cooperative food-gathering and food-sharing. Subsistence remains a strong, positive thematic value that binds families, communities and northwest Inupiat people together as distinctive social groups.

The current subsistence use areas of Kivalina and Noatak residents that overlap the project area were recently described and mapped by Braund & Associates (1983). The two communities make common use of some subsistence resource areas. However, a 1972 survey (Mauneluk Association, 1974) of overall harvest patterns found distinctive differences in the subsistence orientations of coastal Kivalina and inland Noatak residents (Table IV-12). In general, Kivalina was most heavily dependent on sea mammal and fisheries


ARCTIC OCEAN
CAPE LISBURNE
BROOKS RANGE
POINT HOPE
DE LONG MOUNTAINS
ALASKA MARITIME NATIONAL WILDLIFE REFUGE
CAPE THOMPSON
KIVALINA RIVER
RIVER
NOATAK NATIONAL PRESERVE
RED DOG
SOUTHERN BOUNDARY NORTH SLOPE BOROUGH
DEADLOCK MTN EL. 2,595'
RIVER
68°
WULIK
NOATAK
CHUKCHI SEA
CAPE KRUSENSTERN ARCHEOLOGICAL DISTRICT BOUNDARY
KIVALINA
NOATAK
CAPE KRUSENSTERN NATIONAL MONUMENT
CAPE KRUSENSTERN
50 miles
50 kilometers
HOTHAM INLET
KOBUK RIVER
KOTZEBUE
NOORVIK
ARCTIC CIRCLE
LEGEND
NOATAK
KIVALINA
LOWER KOBUK VALLEY VILLAGES (NORVIK, KIANA)
SUBSISTENCE STUDY BOUNDARY
SELAWIK
VILLAGE LAND SELECTIONS
ARCTIC OCEAN
NOME
FAIRBANKS
ANCHORAGE
GULF OF ALASKA

Source: Mauneluk Association, 1979

FIGURE IV-12 SUBSISTENCE USE BY NORTHWESTERN ALASKA NATIVE VILLAGES

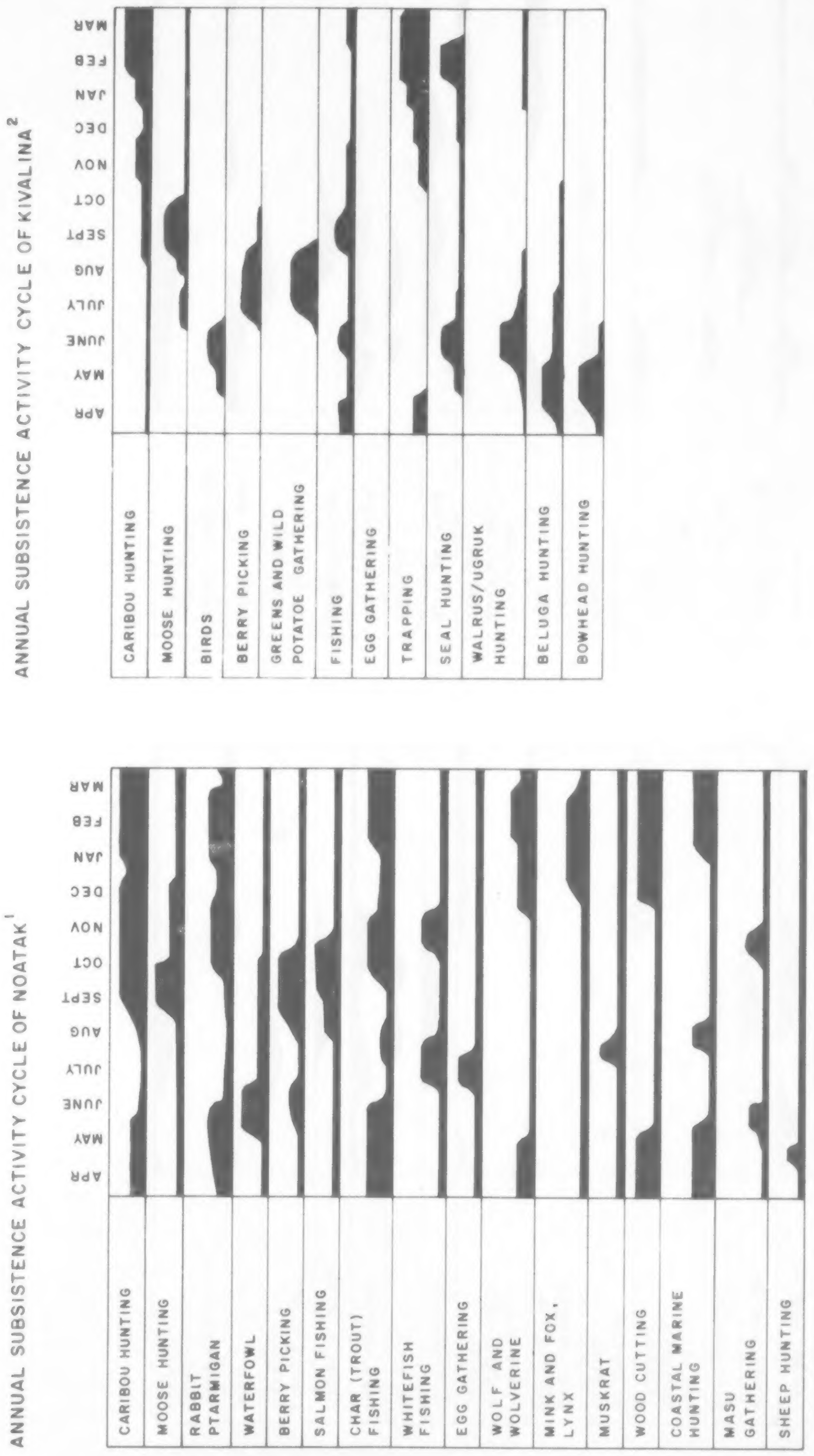


ANNUAL SUBSISTENCE ACTIVITY CYCLE OF THE KUUVANMIIT OF THE UPPER KOBUK RIVER VILLAGES (KOBUK, AMBLER AND SHUNGNAK)[1]

ANNUAL SUBSISTENCE ACTIVITY CYCLE OF THE KUUVANMIIT OF THE LOWER KOBUK RIVER VILLAGES (KIANA AND NORVIK)[1]

1 SOURCE: MAUNELUK ASSOCIATION, 1979

FIGURE IV-13 ANNUAL SUBSISTENCE ACTIVITY CYCLES, UPPER & LOWER KOBUK RIVER VILLAGES



1. SOURCE: MAUNELUK ASSOCIATION, 1979
2. SOURCE: BRAUND & ASSOCIATES, 1983

FIGURE IV-14 ANNUAL SUBSISTENCE ACTIVITY CYCLES, NOATAK & KIVALINA VILLAGES

Table IV-12

SUBSISTENCE RESOURCES HARVESTED FOR KIVALINA AND NOATAK, 1972

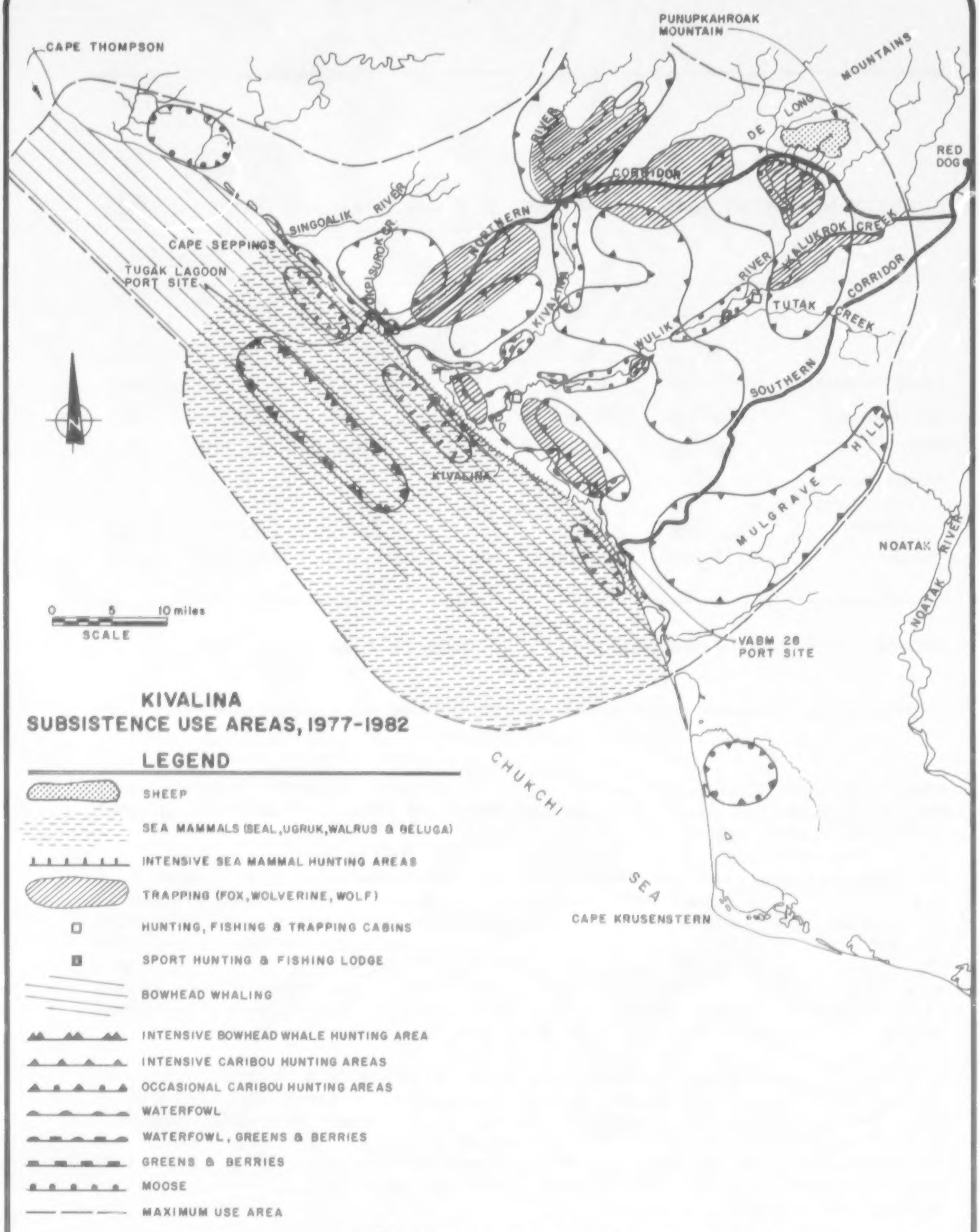
	Kivalina			Noatak		
	kg	lb	Percent of Total	kg	lb	Percent of Total
Land Mammals	23,496	51,800	17.9	61,620	135,850	46.3
Sea Mammals	55,519	122,400	42.3	7,666	16,900	5.8
Fish	50,326	110,950	38.3	60,653	133,718	45.6
Other (water-fowl, berries, greens)	1,988	4,382	1.5	3,057	6,740	1.3
Total	131,329	289,532	100.0	132,996	293,208	100.0

Source: Braund & Associates, 1983 from Mauneluk Association, 1974

harvests, with land mammals seasonally important. Noatak residents were mostly dependent on land mammals and fisheries; sea mammals were of relatively minor importance.

As shown on Figures IV-15 and IV-16, the proposed mine site is located on the fringe of the subsistence areas used by Kivalina and Noatak residents. In addition, the various overland transportation corridors and the port sites cross or fall within subsistence use lands. Numerous coastal areas, the Wulik and Kivalina River drainages, and the Mulgrave Hills are used intensively by caribou hunters from both communities. The region is part of the western Arctic caribou herd's range, but changes in the herd's migration routes and winter range conditions greatly influence hunting success.

Subsistence fishing is important to both Kivalina and Noatak residents throughout the year. The fall run of Arctic char is especially important to both communities, while the Noatak River chum salmon and char runs are locally important. Kivalina marine mammal hunters intensively search the nearshore areas off Kivalina and other spots north and south of Kivalina in season. Both Kivalina and Noatak residents harvest waterfowl in coastal lagoons and wetlands.


CAPE THOMPSON
PUNUPKAHROAK MOUNTAIN
DE LONG MOUNTAINS
RED DOG
CORRIDOR
NORTHERN
RIVER
SINGOALIK RIVER
CAPE SEPPINGS
TUGAK LAGOON PORT SITE
OKPISUROK CR.
KIVALINA
WULIK
RIVER
KALUKROK CREEK
TUTAK CREEK
CORRIDOR
SOUTHERN
KIVALINA
HILL
MULGRAVE
NOATAK
NOATAK RIVER
VABM 28 PORT SITE
0
5
10 miles
SCALE
CHUKCHI
SEA
CAPE KRUSENSTERN
KIVALINA
SUBSISTENCE USE AREAS, 1977-1982
LEGEND
SHEEP
SEA MAMMALS (SEAL, UGRUK, WALRUS & BELUGA)
INTENSIVE SEA MAMMAL HUNTING AREAS
TRAPPING (FOX, WOLVERINE, WOLF)
HUNTING, FISHING & TRAPPING CABINS
SPORT HUNTING & FISHING LODGE
BOWHEAD WHALING
INTENSIVE BOWHEAD WHALE HUNTING AREA
INTENSIVE CARIBOU HUNTING AREAS
OCCASIONAL CARIBOU HUNTING AREAS
WATERFOWL
WATERFOWL, GREENS & BERRIES
GREENS & BERRIES
MOOSE
MAXIMUM USE AREA

SOURCE: BRAUND & ASSOCIATES, 1983

FIGURE IV-15 SUBSISTENCE USE AREAS, KIVALINA VILLAGE

]

Coastal Geologic Processes

Studies by Moore (1966) and Hopkins (1977) indicate that long-term net sediment transport is in a southeasterly direction, though average annual sediment movement takes place perpendicularly to the shoreline. Huge quantities of beach sand (on the order of millions of cubic meters) can be washed out in a single storm and deposited as a bar near the wave break point. For example, on August 9, 1960, Ogotoruk Beach, located 66 km (41 mi) northwest of Kivalina, was lowered 1.0 m (3.3 ft) by waves 15 m (50 ft) long and 1.4 m (4.6 ft) high (Moore, 1966). Sediments subsequently are restored to beaches by more normal sea conditions.

In addition to the huge movement of beach sediment perpendicular to shore, a small component of net sediment movement is directed southeasterly between Point Hope and Cape Krusenstern. Sediment movement can thus be pictured as a zig-zag pattern with a small but important quantity displaced southward in an average year. Over a long period, Moore (1966) estimated that about 22,000 m^3 (28,780 yd^3) of sediment are annually transported along the shore to Sheshalik Spit, 43 km (27 mi) east-southeast of Cape Krusenstern. Quantities of sediment moved vary considerably each year. Woodward-Clyde Consultants (1983) calculated that 82,580 m^3 (108,000 yd^3) of sediment were transported southeast along the coast each year. In some years a reverse movement of sediment may also occur.

Hopkins (1977) calculated that beach erosion between Kivalina and Cape Krusenstern is of the same order of magnitude as the quantity of material deposited in the Cape Krusenstern beach ridge complex. Apparently rivers and streams (such as the Singoalik and Wulik Rivers and Agagrak, Rabbit and Kilikmak Creeks) as well as submerged sand bars serve as sediment sources. Most sediment transport probably occurs in the summer months when winds are predominantly from the west and northwest. Sediment displaced in the winter by ice action is probably insignificant compared to wind-driven sediment transport (Moore, 1966).

Marine Water Quality

The Chukchi Sea typically has relatively warm, low salinity water present near shore. Following ice breakup in late June, freshwater influence near shore is high due to melting ice and high stream runoff. Incoming fresh water dilutes nearshore surface waters in summer so that salinities range from 22 to 29 parts per thousand (ppt). Colder, deeper water and water farther offshore typically has salinities ranging from 31 to 33 ppt. There is a trend for salinity to increase in surface waters from late June through late August. Seawater temperatures along the coast are generally quite warm (11° to 14°C [52° to 57°F]). No significant cooling or warming trend occurs over the summer, nor are seawater temperatures significantly warmer (greater than 0.5°C difference) nearshore compared to offshore.

Temperature and salinity measurements were taken in the study area during the open water period of 1982 (Dames & Moore, 1983a). In general, temperature and salinity profiles showed decreasing temperature and increasing salinity values with depth. At deeper stations, the surface water layer was well mixed to a depth of 6 to 8 m (20 to 26 ft), and a sharp thermocline* was present between 8 and 10 m (26 to 33 ft). A thermocline occurs where there is a rapid decrease in water temperature with depth, in this case a 2.1°C (3.8°F) difference in 2 m (6.6 ft). At shallower, more nearshore stations, a less distinct thermocline (1.1°C [2.0°F] temperature change in 2 m [6.6 ft]) occurred between 4 and 8 m (13 and 26 ft) of depth. Salinity varied from 25 ppt at the surface to 31 ppt at a depth of 12 m (40 ft). Lagoons in the study area are highly variable in physical and chemical parameters. Closed lagoons tend to be mostly freshwater with a slight brackish nature near their ocean shorelines. Open lagoons are normally more saline near the opening and fresher near the creek and river mouths.

Ice Conditions

Sea ice generally begins to form on the coast in early October, but periodic high winds and waves may delay formation of solid cover until January. Sea ice normally reaches a thickness of 2 to 3 m (6.6 to 9.8 ft) during the course of the winter, but can reach greater depths when it is piled up due to storm driven currents. Melt pools and cracks begin to form in May and June, and the ice cover usually disappears by early July. The edge of landfast ice is usually 3 to 8 km (2 to 5 mi) offshore in an average winter. The edge of landfast ice usually approximates the 9.2 m (30 ft) depth contour where it can contact the bottom when it is piled into ridges. Landfast ice, though stable through winter, is subject to movement during break-up.

Pack ice generally retreats north of Point Hope in August, September and October. During late winter and spring, pack ice and landfast ice are usually separated by a shear zone approximately 64 to 80 km (40 to 50 mi) wide with open leads present.

Shore ice pile-up has been observed on the Chukchi and Beaufort Sea coasts to heights of over 9.2 m (30 ft) up to 9.2 m (30 ft) onto the beach. The same pile-up heights could occur on offshore structures. Ice run-up has been observed also when relatively thin sheets of ice (0.6 to 1.5 m [2 to 5 ft] thick) run up beaches as far as 92 m (300 ft) from the water's edge. Ice run-up reached heights of 9.2 m (30 ft) above the beach water line.

Meteorology and Air Quality

Meteorology

When the Chukchi Sea is generally ice-free (late June through early October), the coast of the project area is dominated by a polar maritime climate, with cooler air temperatures, more frequent fog and clouds, and stronger westerly winds compared to the inland transportation corridors and the De Long Mountains. The summer inland climate is more continental with greater sunshine, greater daily temperature swings and variable winds. In winter months, climate is generally similar on the seacoast and inland, with some differences in wind, precipitation and temperature depending on proximity to the De Long Mountains. Mountain locations would have more variable winds, greater precipitation and warmer temperatures compared to coastal locations.

---

* Defined in Glossary.

Meteorological data applicable to the Red Dog project area were available for Kotzebue, Point Hope and Cape Lisburne from the National Climatic Center. Comprehensive meteorological records were also available for a two-year period from Ogotoruk Valley (Project Chariot) at Cape Thompson, 65 km (40 mi) northwest of Kivalina. A compilation of climatological data for the coastal regions was available in Brower et al. (1977).

Near the seacoast, typical summer temperatures range from 4° to 13°C (39° to 55°F) and winter temperatures range from -26° to -15°C (-15° to 5°F). Seacoast temperature extremes are -47°C (-53°F) in winter and 29°C (84°F) in summer. In the De Long Mountain foothills, summer temperatures typically fluctuate between 2° and 18°C (36° and 64°F), with extreme high temperatures near 32°C (90°F). The winter inversion layer usually lies below the higher hills and ridges of the De Long Mountains, so extreme winter low temperatures occur less frequently in the mountains.

Mean monthly cloudiness over the seacoast ranges from 50 to 80 percent, with most clear days occurring in winter. Fog occurs about 10 percent of the time on the coast. The sun is continuously above the horizon for approximately seven weeks centered around June 22 (the summer solstice). Due to orographic* shading by the De Long Mountains, the sun sets for a few hours in Red Dog Valley, even in June. The sun is continuously below the horizon for approximately four weeks centered around December 22 (the winter solstice). A minimum of 4 to 5 hours of twilight adequate for outdoor activities occurs during this time.

Mean annual precipitation on the seacoast and coastal lowland is approximately 25 cm (10 in). Orographic effects cause precipitation to increase to 38 cm (15 in) on the coastal upland, and precipitation ranges from 51 to 76 cm (20 to 30 in) in the De Long Mountains. Nearly half of the mean annual precipitation occurs as rain during the three months of July through September. August is the wettest month of the year, receiving one-quarter of the annual precipitation. Mean annual evaporation from lakes and wetlands in Arctic conditions found in the foothills of the De Long Mountains varies from 15 to 23 cm (6 to 9 in). Most of this evaporation occurs from May through August.

Snowfall has been recorded every month of the year, but consistent snow cover generally occurs only from the middle of October to the middle of May. Maximum snow depths have reached 1.2 m (4 ft), but typical late winter depths are 0.6 m (2 ft). Considerable blowing and drifting of snow occurs in coastal locations and on exposed peaks and ridges. In these windy areas, strong east to northeast winds create bare ground over 30 to 40 percent of the area. Snowdrifts 1.8 to 3.0 m (6 to 10 ft) deep accumulate in depressions and in the lee of banks.

---

* Defined in Glossary.

There are marked seasonal differences in wind regime, particularly on the seacoast. In winter the Arctic Front and associated storm tracks are normally far to the south. The Polar Cold High generates strong north to east winds with the direction depending on local topography. Predominate winds on the seacoast and the coastal upland are easterly, down the Wulik River valley and parallel to the southern edge of the Brooks Range. During winter this direction predominates over 60 percent of the time, with mean annual wind speeds for all directions of 5 to 6 m/s (10 to 12 knots). When low pressure centers are present in the Chukchi Sea, strong southeast winds blow parallel to the coast.

Summer winds in the coastal areas are much more variable than during winter, and speeds decrease to a mean of 4 to 5 m/s (8 to 10 knots). West to northwest winds occur approximately 50 percent of the time, while east to northeast winds occur 35 percent of the time. Most of the west and east winds result from a sea breeze circulation that develops in late spring after break-up. The strongest summer winds (south to southeast) are associated with low pressure centers in the Chukchi Sea and may have maximum wind speeds of 35 m/s (70 knots).

In the vicinity of the De Long Mountain foothills and in Red Dog Valley, local topography strongly influences wind direction and velocity. Predominate winter winds (north to northeast) are channeled by the valleys of the Wulik River, Ikalukrok Creek, and the North and South Forks of Red Dog Creek. Mean annual wind speeds average 2.5 to 3 m/s (5 to 6 knots) in Red Dog Valley. Near calm conditions can be expected 20 percent of the time on the valley floor due to local cold air pooling.

Summer winds in the De Long Mountain foothills are controlled by local valley circulation patterns. Up-slope winds occur during the day, and light down-slope or down-valley winds typically occur at night. Occasional strong southerly winds may occur in association with storm systems approaching from the west.

Air Quality

There are no significant air pollutant sources in northwestern Alaska. Therefore, background levels in the Red Dog project area are assumed to be negligible. From measurements taken in similar remote areas, air pollutant concentrations are probably less than follows: particulates 30 $\mu g/m^3$, nitrogen dioxides 10 $\mu g/m^3$, sulfur dioxide 3 $\mu g/m^3$, ozone 60 $\mu g/m^3$ and carbon monoxide 500 $\mu g/m^3$.

Natural particulate levels are probably high during strong winds due to lack of soil-protecting vegetation on hilltops and ridge crests. Observations at Cape Thompson showed that strong winter winds created large bare areas which generated surface dust deposits on snow cover downwind. High concentrations of smoke particulates may also occur as a result of rare summer tundra fires.

Visual Resources

Basic methods used to determine the value of visual resources have been developed by the U.S. Forest Service in its Visual Resources Management (VRM) Program. The visual characteristics of a landscape include visual variety, the number and interest of viewers, and the land's ability to visually change without losing its inherent character. Visual variety has been shown to be a good predictor of viewer preference. The number, interest and location of viewers are also factors used to identify visually important areas.

For any particular area, visual variety classes are determined based on the relative value of the surrounding area. For example, lands with visual variety typical of the region are classified as "common" or Class B lands. Areas with special patterns of vegetation, water or landforms are considered "distinctive" or Class A lands. Areas with very little variety or interest are considered "minimal" or Class C lands.

The Red Dog project area, including the De Long Mountains, the Mulgrave Hills, and the Kivalina and Wulik River basins, is highly scenic relative to the lower 48 states. A majority of the project area is rated variety Class A. Highly rated areas include the shoreline, the larger rivers and adjacent lakes, notable hills, and the more mountainous areas to the north and east. The remainder of the landscape is considered Class B. None of the landscape is considered variety Class C.

The VRM system combines data on the number and interest of viewers to determine a sensitivity rating for any particular area. Because of its remoteness and the limited number of use areas (those being the village of Kivalina and Cape Krusenstern National Monument), the general visual sensitivity of the project area is considered to be low. Cape Krusenstern National Monument is considered an area of high sensitivity based on projections of future use.

The VRM program combines data on visual variety classes with sensitivity ratings to determine Visual Quality Objective (VQO) zones. Five general VQO zones are defined as follows:

- Preservation - No visual changes permitted.
- Retention - Visual changes must blend with the form, line, color and texture of the existing landscape.
- Partial Retention - Visual changes must be subordinate to and borrow visual elements from the natural landscape.
- Modification - Major visual changes are allowed, but changes must borrow from existing visual elements of the landscape.
- Maximum Modification - Major visual changes allowed. Conformity with the natural landscape is not required.

VQO zones defined in the study area are shown on Figure IV-11. The Wulik and Kivalina River basins, and the Mulgrave Hills in Cape Krusenstern National Monument are classified as retention level quality. The remainder of the project area is generally classified as partial retention quality. In general, the project area is high in visual variety but low in visual sensitivity.

Red Dog project components occur in landscapes with varying visual characteristics. The northern transportation corridor passes through areas of both high and moderate visual variety. The southern transportation corridor is located predominantly in an area of moderate visual variety, but is close to viewers in Cape Krusenstern National Monument. The northern transportation corridor passes through retention quality areas, while the southern corridor lies within partial retention areas. The port sites are located in areas of high visual variety and partial retention quality.

Sound

The Red Dog project area is located in a remote region of northwestern Alaska. The closest communities are the small Native villages at Kivalina (located on the coast 32 km [20 mi] northwest of the proposed southern port site), and at Noatak (located 42 km [26 mi] south of Red Dog Valley). Data from similar remote locations indicate that typical natural noise levels usually range from 15 to 45 dB(A), which is considered quiet (see Table V-7 for comparison values). Natural noise levels up to 65 dB(A) may be associated with storms and wildlife. Areas along the coast would have the highest noise level due to strong winds, breaking waves, ice movements, marine mammal cries and bird calls. Maximum natural noise levels along the proposed transportation corridors and in the De Long Mountains would be caused by wind, rain, wildlife and rare thunder.

Noise associated with the Native communities would not be discernable in most of the project area, except that resulting from subsistence hunting activities (use of snowmobiles, outboard motors and float planes). These types of activities typically generate noise levels up to 85 dB(A) at 15 m (50 ft). Noise is presently being generated by temporary mining exploration activities concentrated in the De Long Mountains. Infrequent helicopter and light plane overflights at low altitudes may also occur in the project area. These flights would generate ground level noise up to 90 dB(A).

Cultural Resources

It is generally accepted that the first Asian immigrants to the North American continent crossed the Bering Strait (Beringia), arriving in what is now Alaska in the area of the Seward and Lisburne peninsulas. They then moved eastward, probably north of the Brooks Range, into the Canadian interior and southward east of the Rocky Mountain chain. This movement is generally thought to have occurred toward the close of the Wisconsin glacial advance, perhaps 10,000 to 15,000 years ago, although many scholars have postulated the initial date of immigration at 80,000 to 100,000 years.

The Alaskan link between Asia and the early human sites in the interior, while widely accepted in theory, is not well-documented in fact. Tangible

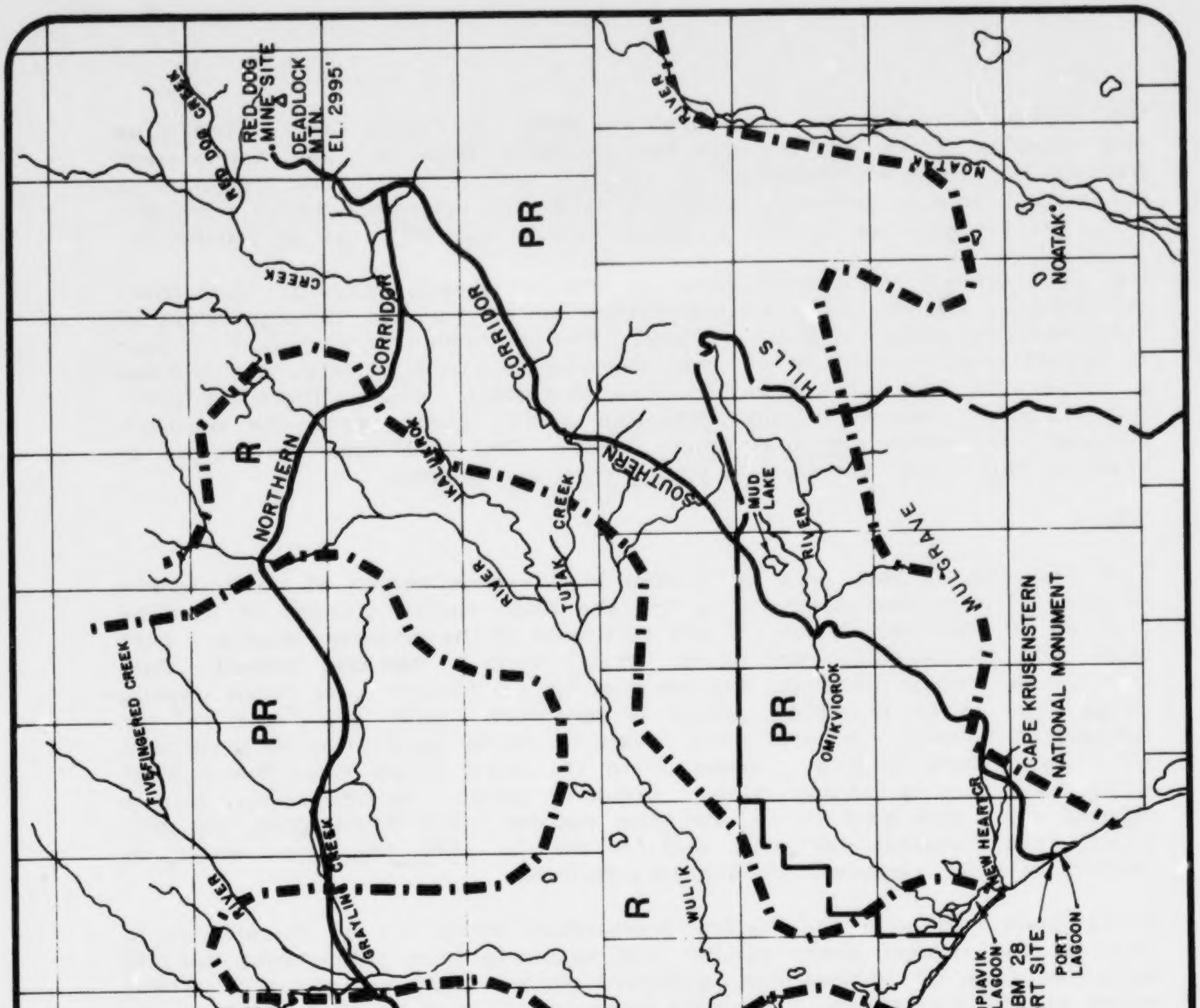

RED DOG CREEK
RED DOG MINE SITE
DEADLOCK MTN. EL. 2995'
CREEK
NORTHERN CORRIDOR
SOUTHERN CORRIDOR
IKALUKROK
NOATAK RIVER
NOATAK
HILLS
MUD LAKE
RIVER
MULGRAVE
CAPE KRUSENSTERN NATIONAL MONUMENT
TUTAK CREEK
RIVER
OMIKVIOROK
NEW HEART CR
IPIAVIK LAGOON
VABM 28 PORT SITE
PORT LAGOON
FIVEFINGERED CREEK
RIVER
GRAYLING CREEK
WULIK
KIVALINA
IMIKRUK LAGOON
KIVALINA
SEA
CHUKCHI
KIVALINA LAGOON
KAVRORAK LAGOON
TUGAK LAGOON PORT SITE
TUGAK LAGOON
SINGOALIK
RIVER
RIVER
KIPAK
PR
R
PR
R
PR
R
PR
R
6 miles
10 kilometers
LEGEND
MONUMENT BOUNDARY
TRANSPORTATION CORRIDOR
R RETENTION
PR PARTIAL RETENTION

FIGURE IV-11
VISUAL QUALITY
OBJECTIVE ZONES IN PROJECT AREA

evidence may have been inundated as ocean levels rose with the melting of the continental ice sheets. If so, those data are likely lost to bottom scouring or strong ocean floor currents in the Bering Strait area. Site evidence may also have been destroyed or disseminated by glacial action or natural forces associated with land elevation changes resulting from glacial retreat. It may also be that evidence of this earliest occupation has not been discovered, or perhaps simply not recognized. It is fair to conclude that if evidence of these first immigrants is to be found, it will likely be discovered in the region where earliest contact was possible. This would include the Red Dog project area.

The earliest prehistorical remains in the vicinity of the Red Dog project area are located on a series of beach ridges at Cape Krusenstern, and form the core of the Cape Krusenstern National Monument and the Cape Krusenstern Archeological District (Fig. 1-1). The latter classification requires management consideration for any archeological resource in the District (there is a presumed eligibility to the National Register of sites for all recorded and unrecorded sites within the Archeological District). The Cape Krusenstern Archeological District encompasses approximately 809,000 ha (2,000,000 ac) and includes most of the proposed transportation corridors.

While the National Monument constitutes only approximately 25 percent of the District, its existence is predicated on the archeological remains in the area that depict every known cultural period in Arctic Alaska. It is the purpose of the Monument to preserve and interpret evidence of prehistorical and historical Native cultures. The easily visible concentration of house and occupied sites in the Monument are often used as a diachronic* model of human life in northwestern Alaska (Giddings 1967; Giddings and Anderson, in press).

Archeological sites located within the Red Dog project area are typical of interior northwestern Alaska. These sites consist of surface scatters, or shallowly buried deposits of lithic materials that were used in making stone artifacts (Hall, 1982a). The localities served as prehistoric flaking stations associated with upland game procurement, though some may have been ephemeral camps. More permanent settlements are known closer to the coast, although the majority of coastal sites within the project area relate to recent periods (Hall, 1982a,b; 1983a).

Four archeological sites are located in the immediate area of the mine. At least a dozen more archeological localities are within a 3 km (1.9 mi) radius of the mine, mill, tailings pond and water storage facilities complex.

There are 13 archeological sites along the southern transportation corridor (Hall 1982a,b; 1983a). Seven of these sites are within the Cape Krusenstern Archeological District, with six of those sites being within Cape Krusenstern National Monument. The other sites are on state selected or tentatively approved lands. There are 23 archeological sites along the northern transportation corridor (Hall 1982a,b; 1983a). None of these sites are within Cape Krusenstern National Monument or the Cape Krusenstern Archeological District. All 23 sites are on state selected or tentatively approved lands.

---

* Defined in Glossary.

Sites related to coastal activities are located at each port site. There is a small eroding cabin at Tugak Lagoon of which little remains (Hall, 1983a). A reindeer herding facility is present on private land at the VABM 28 port site which may provide physical documentation for the historical reindeer herding activity in this area.

The upland hunting sites of the Red Dog project area may reflect seasonal use of the interior during months of resource unavailability at the coast. Similar sites which reflect inland travel from Cape Krusenstern have been noted for the De Long Mountains (Smith, 1982; Hall, 1982a,b; 1983a).

Subsistence

Subsistence is vital to the economic well being and nutrition of most of the region's residents. The extent of its importance is indicated by the findings of a 1978 survey of about one-third of the region's households. Approximately 55 percent of all households estimated they obtained half or more of their food supply by subsistence hunting, fishing and gathering (Table IV-11). This survey found that subsistence dependence was widespread throughout the region, but much more pronounced in the outlying villages, including Kivalina and Noatak, than in Kotzebue. In a region where imported foodstuffs are costly and cash income depressed, the economic importance of the subsistence food supply is evident. Within this general reliance on subsistence, there is a great deal of variation from settlement to settlement, season to season, and year to year in subsistence harvest patterns (Social Research Institute, 1982).

The region encompasses a great diversity of terrestrial, freshwater, marine and wetland habitat types which support many valuable subsistence species. Virtually the entire region and most of its nearshore marine waters fall within the subsistence use area of one or more villages (Fig. IV-12).

Among the most important subsistence food resources are land mammals (caribou, moose), fish (Arctic char, chum salmon, sheefish, whitefish, tomcod, smelt), sea mammals (bearded, ringed and spotted seals; belukha whales) and waterfowl. However, nearly all edible animal species are used to add variety to the customary diet or in times of scarcity. Berries and other wild plant foods are also extensively gathered for consumption.

Most of these subsistence resources (e.g., caribou, Arctic char, salmon, marine mammals, plant foods) are either migratory or highly seasonal; the period of their peak availability is often very brief and localized. Thus, the yearly cycle of subsistence harvest activites for each settlement reflects closely the timing and specific mix of locally available resources. Figures IV-13 and IV-14 show typical annual subsistence activity cycles for Kivalina, Noatak, and other selected community groups in the region. However, it should be stressed that the "typical year" rarely occurs because the pattern of resource availability is so unstable. Adaptation to these uncertain circumstances has produced a highly complex, diverse, and flexible pattern of subsistence activity that continually adapts to harvest opportunities.

Table IV-11

NANA REGION
HOUSEHOLD DEPENDENCY ON SUBSISTENCE HARVEST[1]
PERCENT DISTRIBUTION

	NANA Region	Kivalina	Noatak	Kotzebue	Other Villages[2]
All	7.5	5.6	--	5.6	12.4
Most	24.8	16.7	57.1	14.9	30.1
Half	23.2	38.9	28.6	16.1	27.5
Some	36.1	38.9	14.3	49.1	27.5
None	8.5	--	--	14.3	2.6
TOTAL	100.0	100.0	100.0	100.0	100.0

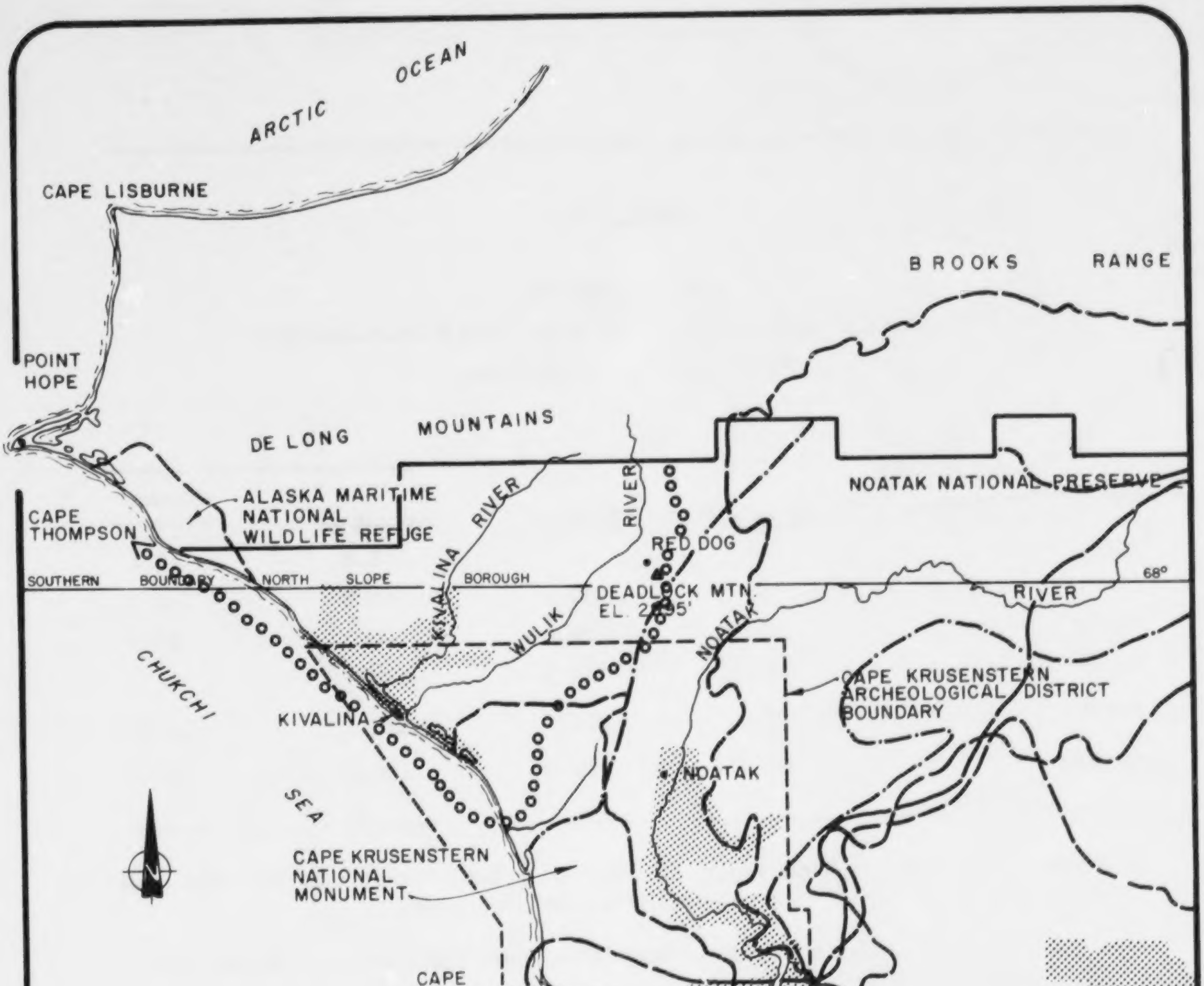
[1] Reply to question: How much of your own food would you say you and your family gathered, hunted or fished for this year?

[2] Other villages include Ambler, Buckland, Deering, Kiana, Kobuk, Noorvik, Selawik and Shungnak.

Source: NANA Regional Strategy, Community Survey, 1978

In addition to its economic importance, subsistence is essential in structuring and sustaining the region's cultural values and social organization. It sustains the important cultural practices of cooperative food-gathering and food-sharing. Subsistence remains a strong, positive thematic value that binds families, communities and northwest Inupiat people together as distinctive social groups.

The current subsistence use areas of Kivalina and Noatak residents that overlap the project area were recently described and mapped by Braund & Associates (1983). The two communities make common use of some subsistence resource areas. However, a 1972 survey (Mauneluk Association, 1974) of overall harvest patterns found distinctive differences in the subsistence orientations of coastal Kivalina and inland Noatak residents (Table IV-12). In general, Kivalina was most heavily dependent on sea mammal and fisheries


ARCTIC OCEAN
CAPE LISBURNE
BROOKS RANGE
POINT HOPE
DE LONG MOUNTAINS
ALASKA MARITIME NATIONAL WILDLIFE REFUGE
CAPE THOMPSON
KIVALINA RIVER
RIVER
RED DOG
NOATAK NATIONAL PRESERVE
SOUTHERN BOUNDARY NORTH SLOPE BOROUGH
DEADLOCK MTN. EL. 2695'
NOATAK
RIVER
68°
WULIK
CHUKCHI SEA
KIVALINA
CAPE KRUSENSTERN ARCHEOLOGICAL DISTRICT BOUNDARY
NOATAK
CAPE KRUSENSTERN NATIONAL MONUMENT
CAPE KRUSENSTERN
HOTHAM INLET
KOBUK RIVER
NOORVIK
KOTZEBUE
50 miles
50 kilometers
ARCTIC CIRCLE
LEGEND
NOATAK
KIVALINA
LOWER KOBUK VALLEY VILLAGES (NORVIK, KIANA)
SUBSISTENCE STUDY BOUNDARY
SELAWIK
VILLAGE LAND SELECTIONS
ARCTIC OCEAN
NOME
FAIRBANKS
ANCHORAGE
GULF OF ALASKA

Source: Mauneluk Association, 1979

FIGURE IV-12 SUBSISTENCE USE BY NORTHWESTERN ALASKA NATIVE VILLAGES

ANNUAL SUBSISTENCE ACTIVITY CYCLE OF THE KUUVANMIIT OF THE UPPER KOBUK RIVER VILLAGES (KOBUK, AMBLER AND SHUNGNAK)[1]

ANNUAL SUBSISTENCE ACTIVITY CYCLE OF THE KUUVANMIIT OF THE LOWER KOBUK RIVER VILLAGES (KIANA AND NORVIK)[1]

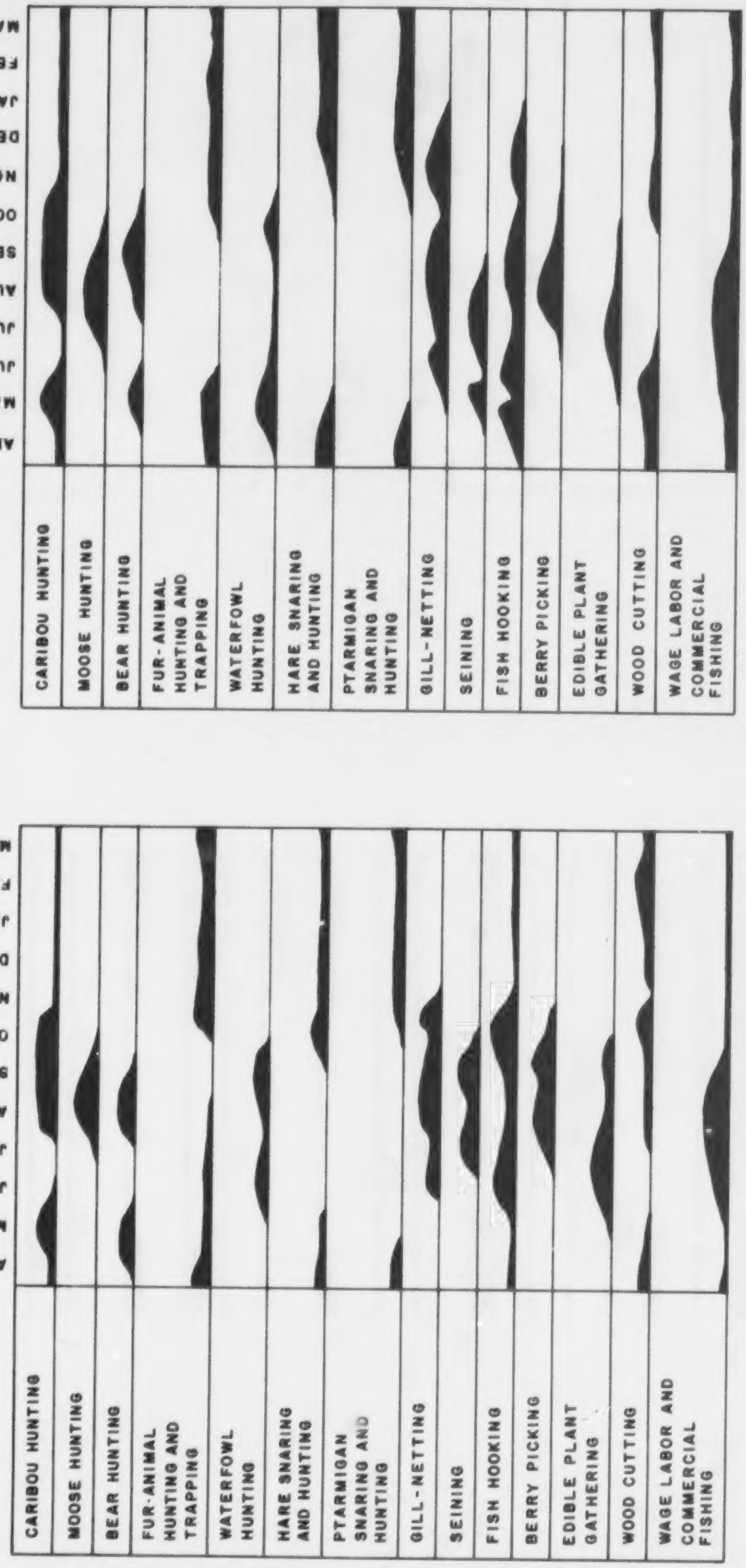
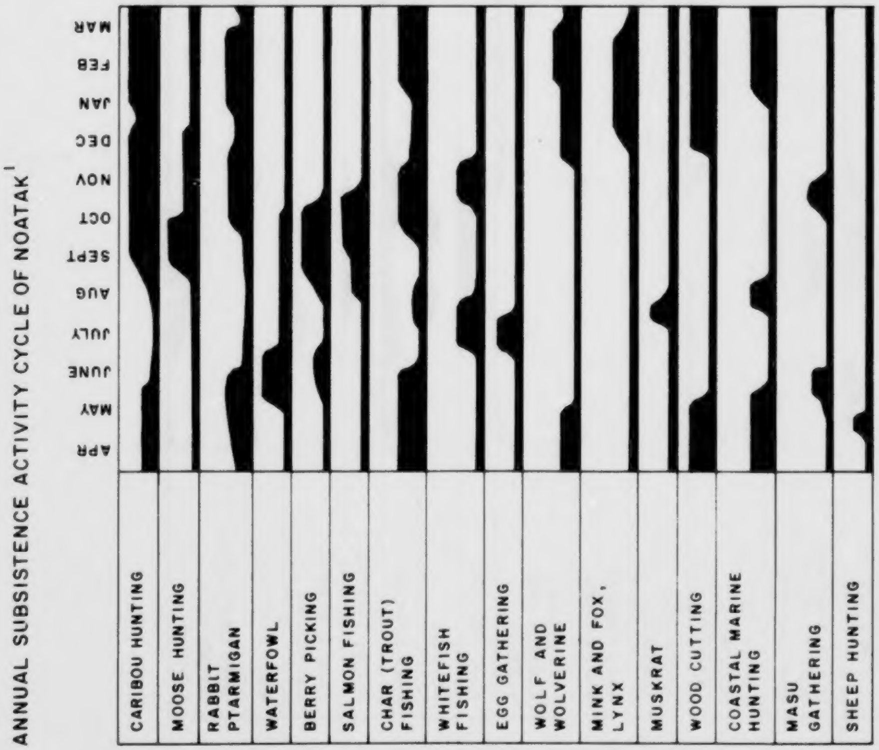
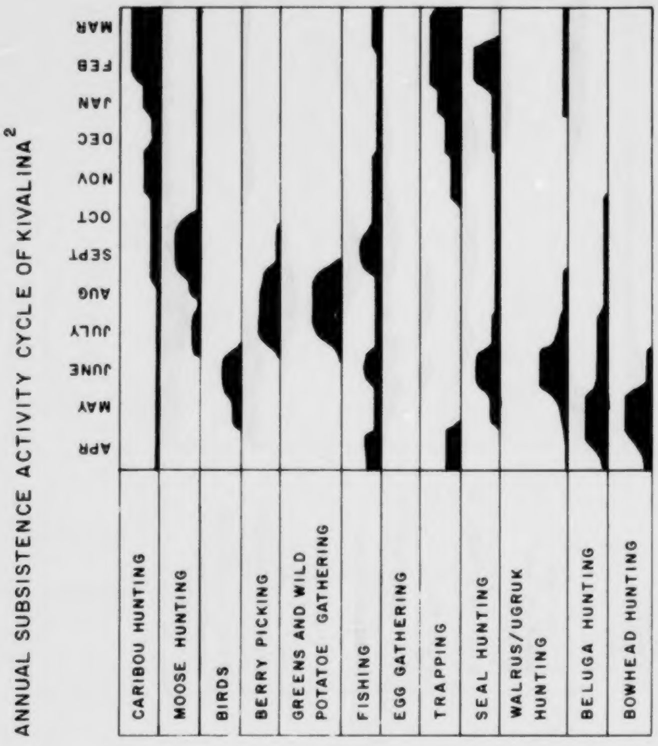


FIGURE IV-13 ANNUAL SUBSISTENCE ACTIVITY CYCLES, UPPER & LOWER KOBUK RIVER VILLAGES

---

[1] SOURCE: MAUNELUK ASSOCIATION, 1979


ANNUAL SUBSISTENCE ACTIVITY CYCLE OF NOATAK[1]


ANNUAL SUBSISTENCE ACTIVITY CYCLE OF KIVALINA[2]

1. SOURCE: MAUNELUK ASSOCIATION, 1979
2. SOURCE: BRAUND & ASSOCIATES, 1983

FIGURE IV-14 ANNUAL SUBSISTENCE ACTIVITY CYCLES, NOATAK & KIVALINA VILLAGES

Table IV-12

SUBSISTENCE RESOURCES HARVESTED FOR KIVALINA AND NOATAK, 1972

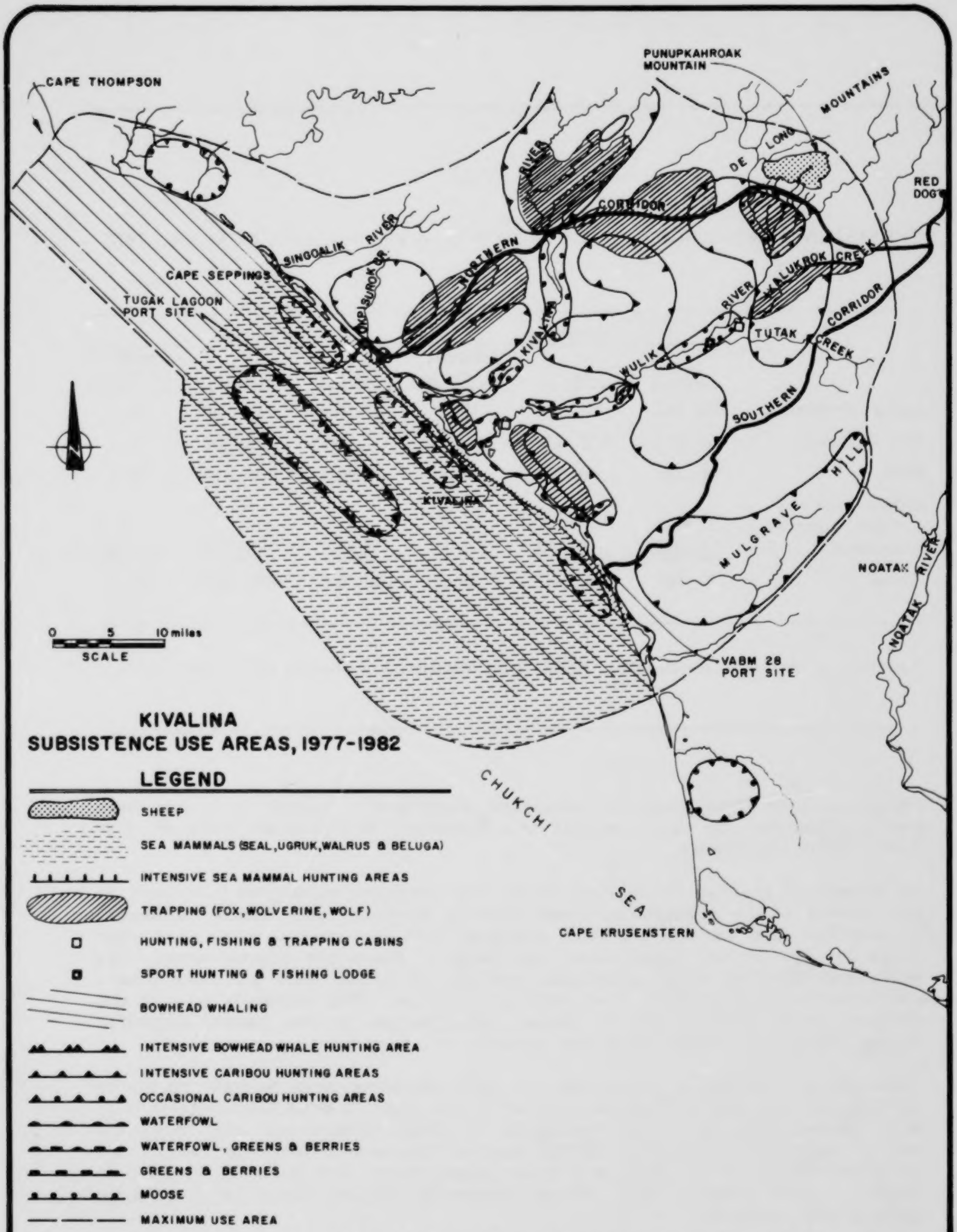
	Kivalina			Noatak		
	kg	lb	Percent of Total	kg	lb	Percent of Total
Land Mammals	23,496	51,800	17.9	61,620	135,850	46.3
Sea Mammals	55,519	122,400	42.3	7,666	16,900	5.8
Fish	50,326	110,950	38.3	60,653	133,718	45.6
Other (waterfowl, berries, greens)	1,988	4,382	1.5	3,057	6,740	1.3
Total	131,329	289,532	100.0	132,996	293,208	100.0

Source: Braund & Associates, 1983 from Mauneluk Association, 1974

harvests, with land mammals seasonally important. Noatak residents were mostly dependent on land mammals and fisheries; sea mammals were of relatively minor importance.

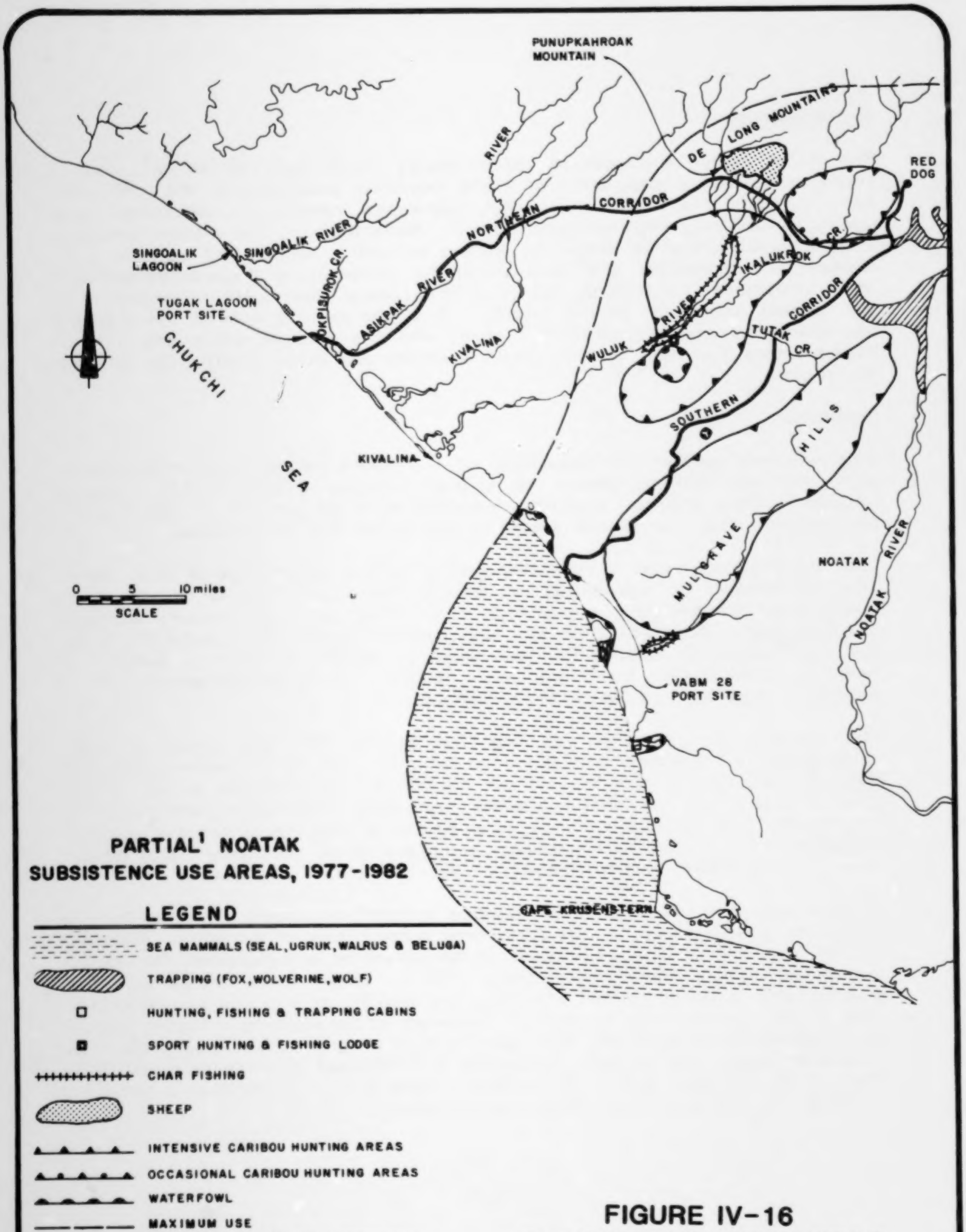
As shown on Figures IV-15 and IV-16, the proposed mine site is located on the fringe of the subsistence areas used by Kivalina and Noatak residents. In addition, the various overland transportation corridors and the port sites cross or fall within subsistence use lands. Numerous coastal areas, the Wulik and Kivalina River drainages, and the Mulgrave Hills are used intensively by caribou hunters from both communities. The region is part of the western Arctic caribou herd's range, but changes in the herd's migration routes and winter range conditions greatly influence hunting success.

Subsistence fishing is important to both Kivalina and Noatak residents throughout the year. The fall run of Arctic char is especially important to both communities, while the Noatak River chum salmon and char runs are locally important. Kivalina marine mammal hunters intensively search the nearshore areas off Kivalina and other spots north and south of Kivalina in season. Both Kivalina and Noatak residents harvest waterfowl in coastal lagoons and wetlands.


CAPE THOMPSON
PUNUPKAHROAK MOUNTAIN
DE LONG MOUNTAINS
RED DOG
SINGOALIK RIVER
CAPE SEPPINGS
TUGAK LAGOON PORT SITE
OKPISUROK CR.
NORTHERN CORRIDOR
RIVER
KIVALINA
WULIK RIVER
WALUKROK CREEK
TUTAK CREEK
SOUTHERN CORRIDOR
KIVALINA
MULGRAVE HILLS
NOATAK
NOATAK RIVER
VABM 28 PORT SITE
0 5 10 miles
SCALE
CHUKCHI SEA
CAPE KRUSENSTERN
KIVALINA
SUBSISTENCE USE AREAS, 1977-1982
LEGEND
SHEEP
SEA MAMMALS (SEAL, UGRUK, WALRUS & BELUGA)
INTENSIVE SEA MAMMAL HUNTING AREAS
TRAPPING (FOX, WOLVERINE, WOLF)
HUNTING, FISHING & TRAPPING CABINS
SPORT HUNTING & FISHING LODGE
BOWHEAD WHALING
INTENSIVE BOWHEAD WHALE HUNTING AREA
INTENSIVE CARIBOU HUNTING AREAS
OCCASIONAL CARIBOU HUNTING AREAS
WATERFOWL
WATERFOWL, GREENS & BERRIES
GREENS & BERRIES
MOOSE
MAXIMUM USE AREA

SOURCE: BRAUND & ASSOCIATES, 1983

FIGURE IV-15 SUBSISTENCE USE AREAS, KIVALINA VILLAGE


PUNUPKAHROAK MOUNTAIN
DE LONG MOUNTAINS
RED DOG
NORTHERN CORRIDOR
SINGOALIK LAGOON
SINGOALIK RIVER
TUGAK LAGOON PORT SITE
OKPISUROK CR.
ASIKPAK RIVER
RIVER
KIVALINA
IKALUKROK CR.
WULUK RIVER
TUTAK CR.
SOUTHERN CORRIDOR
HILLS
CHUKCHI SEA
KIVALINA
0 5 10 miles
SCALE
MULGRAVE
NOATAK
NOATAK RIVER
VABM 28 PORT SITE
CAPE KRUSENSTERN
PARTIAL[1] NOATAK
SUBSISTENCE USE AREAS, 1977-1982
LEGEND
SEA MAMMALS (SEAL, UGRUK, WALRUS & BELUGA)
TRAPPING (FOX, WOLVERINE, WOLF)
HUNTING, FISHING & TRAPPING CABINS
SPORT HUNTING & FISHING LODGE
CHAR FISHING
SHEEP
INTENSIVE CARIBOU HUNTING AREAS
OCCASIONAL CARIBOU HUNTING AREAS
WATERFOWL
MAXIMUM USE

1 THIS RESEARCH ONLY ADDRESSED USE AREAS POTENTIALLY AFFECTED BY RED DOG PROJECT DEVELOPMENT & NOT ALL NOATAK RESOURCE USE AREAS.

SOURCE: BRAUND & ASSOCIATES, 1983

FIGURE IV-16
SUBSISTENCE USE AREAS, NOATAK VILLAGE

Socioeconomics

The NANA region encompasses approximately 93,000 km^2 (36,000 mi^2) and 11 settlements with a population of 4,830 residents according to the 1980 census. Overall, the region is sparsely populated, relatively undeveloped, and lacking a unifying regional government. Nevertheless, the villages comprise a true region which is linked by strong economic, ethnic and cultural ties; common transportation and communications systems; and governmental and other important institutional bonds. The coastal community of Kotzebue is the largest settlement in the region. It is the natural hub of the region's transportation and distributive system, and the administrative and service headquarters for most of the public agencies and other institutions serving the region.

Population

Approximately half of the population of the NANA region lives in Kotzebue, with the rest spread among 10 smaller villages (Table IV-13). Alaska Natives, mainly Inupiat Eskimos, comprise about 84 percent of the region's population. Most non-Native people in the region live in Kotzebue.

The region's population is relatively young, with a median age of 21.6 years. The distribution by age group has become fairly even (Table IV-14), indicating that the period of very high birth rates and rapid natural increase has subsided. Males (53.7 percent) outnumber females (46.3 percent), especially through the post-school age groups, which suggests a pattern of selective outmigration by young adult females. Average household size is relatively large (4.2 persons per household).

The region's population growth rate from 1970 to 1980 was moderate, averaging about 1.8 percent annually. Apparently, natural increase contributed most to the region's growth. All of the region's communities except Noatak grew in size. Intraregional migration is common. Population mobility within the region is high, especially between Kotzebue and the hinterland villages. Movement into Kotzebue is probably in response to employment and educational opportunities, and to Kotzebue's superior public services.

A base case (i.e., without the Red Dog project) population forecast for the region as a whole and for the individual communities of Kotzebue, Kivalina, Noatak and Point Hope was prepared to serve as a benchmark for impact assessment (Kevin Waring Associates, 1983). Based on a review of demographic and economic trends affecting the region, an average annual growth rate of 1.5 percent was chosen for purposes of forecasting a future benchmark population. Assuming this general rate of growth and using the 1982 population base, the region's population was forecast to increase to 6,019 by 1990, 6,985 by 2000 and 8,110 by 2010 (Table IV-15). Kotzebue is expected to retain its role as the region's main settlement.

Table IV-13

POPULATION TRENDS, 1960 TO 1982
STUDY AREA COMMUNITIES

	1960	1970	1980	1982
Ambler	70	169	192	202
Buckland	87	104	177	217
Deering	95	85	150	158
Kiana	253	278	345	364
Kivalina	142	188	241	253
Kobuk	54	-	62	64
Kotzebue	1,290	1,696	2,054	2,470
Noatak	275	293	273	-
Noorvik	384	462	492	518
Selawik	348	429	535	602
Shungnak	135	165	202	214
Kobuk Census Division	3,560	4,048	4,831	-
Point Hope	324	386	461	544

Sources: U.S. Census of Population; Alaska Department of Labor, 1983

Table IV-14

DISTRIBUTION OF POPULATION, BY AGE AND SEX
KOBUK CENSUS DIVISION, 1980

	Male		Female		Total	
Age Group	No.	%	No.	%	No.	%
Less than 5 years	293	11.3	278	12.4	571	11.8
5 - 9	293	11.3	244	10.9	537	11.1
10 - 14	287	11.1	242	10.8	529	11.0
15 - 19	332	12.8	276	12.3	608	12.6
20 - 24	247	9.5	263	11.8	510	10.6
25 - 29	270	10.4	193	8.6	463	9.6
30 - 34	199	7.7	152	6.9	351	7.3
35 - 44	238	9.2	177	7.9	415	8.6
45 - 54	193	7.4	184	8.2	377	7.8
55 - 64	115	4.4	106	4.7	221	4.6
65 plus	127	4.9	122	5.5	249	5.2
Total	2,594	100.0	2,237	100.0	4,831	100.0
Median Age	21.7		21.5		21.6	

Source: U.S. Census of Population, 1980

In general, it is anticipated that the region's future population structure will tend toward a more normal age distribution. The ratio of minors will likely decline and the number of young adults and, especially, older residents will rise as a share of the total population. Corollaries of these trends will be smaller average family and household sizes, lowered dependency ratios, and, potentially, a relatively larger resident workforce.

Table IV-15

BASELINE POPULATION FORECAST
NANA REGION, 1982 TO 2010

	1982[1]	1990	2000	2010
Kivalina	253	285	331	384
Kotzebue	2,470	2,782	3,229	3,749
Noatak	273[2]	317	367	427
Rest of Region	2,339	2,635	3,058	3,550
Total	5,343	6,019	6,985	8,110
Point Hope	544	612	711	826

Source: Kevin Waring Associates, 1983

[1] Actual values.
[2] 1980 Census figure.

Economy

The NANA region has a mixed economy, combining traditional subsistence economic activities with a growing cash economy supported by cash employment and other sources of cash income. Subsistence is vital to the region's livelihood and will continue to be for the foreseeable future. It commands significant expenditures of funds and time, and contributes importantly to the food economy.

A comparison of gross employment and income data for 1970 and 1980 indicates that there has been substantial aggregate growth in the cash economy during the past decade. Total employment grew about 124 percent over the decade while the region's population grew by about 19 percent. The percent of total population employed nearly doubled from about 16 percent in 1970 to about 30 percent by 1980. However, this aggregate growth was accomplished with very little change in the region's basic economic structure. In developmental terms, the region's economy has been static.

The economic multiplier is typically low for underdeveloped rural Alaskan economies with little basic private employment and a strong subsistence component. The mix of goods and services provided locally is limited by small regional market size and low purchasing power. However, this mix has improved over the past decade with the maturation of the region's cash economy. A low economic multiplier suggests that, apart from labor and essential transportation services, the region's economy may have few needed goods and services to supply to new resource development projects.

Table IV-16 compares the distribution of employment by economic sector in 1970 and 1980. The outstanding constant feature was the dominance of public sector employment and the negligible importance of private sector basic employment. At both times, the public sector accounted for better than 60 percent of all employment, even though there was a wholesale shift in the balance between federal and state/local government employment. Government employment showed the biggest growth, and nearly all of that growth was in state and local government employment. There was also strong but lesser growth in services and minor growth in the construction industry. On the other hand, the share of employment held by trade and transportation fell somewhat. Overall, the structure of the region's basic economy changed little, despite substantial aggregate growth.

While job and real income growth in the region greatly outpaced population growth during the 1970 to 1980 period, factors that contributed to these trends may be ending. Chief among those factors were improved resident access to local employment opportunities, rapid expansion of public sector employment, rising resident educational and occupational skill levels, increased female labor force participation, and the emergence of Native-managed business and public service organizations. In the future, it is plausible that the region's workforce will grow slightly faster than the population as a whole, mainly due to a shift in the age composition of the population. It is also expected that residents will continue to adjust to shifts in the economic outlook through migration within and beyond the region.

Data on sources of personal income (Tables IV-17 and IV-18) show there was little change in the sources of earned personal income by economic sector, although there was a large shift within the governmental sector as state and local government replaced the federal government as the single most important source of earned income. From 1970 to 1980, the share of personal income derived from cash employment, dividends and transfer payments changed very little. The average per capita personal income grew by 237 percent from approximately $2,142 to about $7,225, but still remained well below the statewide average of $12,635.

According to the 1980 U.S. Census, the median household income for the Kobuk region was $17,756, with wide variations among the communities. Kotzebue had by far the highest median income ($23,371), consistent with its more fully developed economic status and the reduced role of subsistence.

On the other hand, less developed communities still heavily dependent on subsistence resources had relatively low median incomes (Kivalina, $8,304; Selawik, $9,750; Noatak, $10,000).

Despite apparent economic improvements, long term unemployment rates show a strong seasonal cycle, but remain relatively high in the region. In 1981, the official average annual unemployment rate was 9.8 percent. The official rate is generally thought to understate actual unemployment, mainly because the labor force participation rate (and, thus, the official unemployment rate)

Table IV-16

DISTRIBUTION OF EMPLOYMENT
KOBUK CENSUS DIVISION, 1970 & 1980

Industry	1970 Number	1970 Percent	1980 Number	1980 Percent
Mining	*	*	*	*
Construction	*	*	81	5.6
Manufacturing	*	*	*	*
Transportation, Communication & Utilities	106	16.6	125	8.7
Trade	100	15.6	133	9.2
Finance, Insurance & Real Estate	*	*	18	1.3
Services	17	2.7	168	11.7
Federal Government	300	46.7	218	15.2
State & Local Government	104	16.3	692	48.1
Miscellaneous	*	*	*	*
Total	641	100.0	1,438	100.0

*Withheld by Department of Labor to avoid disclosure or not available.

Source: Alaska Department of Labor, 1970, 1980

is depressed by the scarcity of employment possibilities. This is offset to some degree by unreported subsistence activities and other self-employment, which are omitted from official tallies.

Table IV-17

SOURCES OF PERSONAL INCOME, BY SECTOR
KOBUK CENSUS DIVISION, 1970 & 1980[1]

Industry	1970 $(000)	1970 Percent	1980 $(000)	1980 Percent
Agriculture	(L)	N/A	(D)	N/A
Mining	(L)	N/A	(D)	N/A
Construction	0	0	1,609	5.6
Manufacturing	147	2.0	(L)	N/A
Transportation & Public Utilities	1,419	19.4	4,244	14.9
Trade	545	7.5	2,044	7.2
Finance, Insurance & Real Estate	(L)	N/A	(D)	N/A
Services	379	5.2	2,852	10.0
Government	4,771	65.4	17,141	60.1
Federal	3,906	53.5	5,006	17.5
State & Local	865	11.9	12,135	42.5
Total	7,296	100.0	28,527	100.0

(D) Not shown to avoid disclosure of confidential information.

(L) Less than $50,000.

[1] By Place of Work

Source: U.S. Department of Commerce, 1982

Table IV-18

PERSONAL INCOME, BY SOURCE
KOBUK CENSUS DIVISION, 1970 & 1980

	1970		1980	
	$	Percent	$	Percent
Net Earned Income	6,761	77.8	26,261	74.8
Dividends	216	2.5	1,178	3.4
Transfer Payments	1,708	19.7	7,544	21.5
Total	$8,685	100.0	$34,983	100.0
Per Capita Total Personal Income	$2,142		$7,225	

Source: U.S. Department of Commerce, 1982

Regular cash employment does not preclude subsistence participation, although some flexibility in work schedules is helpful to adapt to the seasonal cycle of subsistence resources availability. Indeed, some recent studies in the region have found that success in the cash employment economy is associated with a high level of subsistence success.

Community Facilities and Services

The material standard of living in the region's communities has risen substantially over the past decade through widespread construction of basic public facilities and improved public services. Most of the settlements have benefited from ongoing programs to provide better housing, improved water supply and sewer systems, electrification, local high schools, health clinics, improved airports and telecommunications. Community services for public safety, fire protection, health and social welfare, adult education and job training have also generally been upgraded.

Nevertheless, while recognizing the advantages of improvements, the region's communities find it difficult to maintain basic community facilities and services to meet current needs. The cost of public facilities and services is high and local public revenue sources are low in the absence of the tax base normally provided by private economic development. All of the NANA communities are heavily dependent on non-local sources of revenues or non-local public agencies for construction and operation of major community facilities and programs, even when local agencies deliver services. As a result, the localities, including Kotzebue, usually cannot absorb any sudden, large population influx without strain on available resources for housing and community facilities and services, especially without a compensating increase in public revenues. Similarly, many households find it difficult to afford the higher cash outlays for utilities, energy, house payments and other factors associated with an improved standard of living.

Local and Regional Governance

The proposed Red Dog mine site and related facilities fall within the jurisdiction of the North Slope Borough. The surface transportation route alternatives from the mine site to the coast, as well as the port site alternatives, are in the so-called unorganized borough, outside any established local or regional government.

All of the communities of the Kobuk census region, except Noatak which has a traditional Indian Reorganization Act (IRA) council, are incorporated as municipalities under Alaska statutes. There is no regional or borough general purpose government encompassing the NANA region. A number of key functions (education, public housing, coastal management) are provided through special purpose regional agencies.

The North Slope Borough is a fully developed home rule regional government. Among its area-wide powers, two are especially relevant to the mining project: land use planning, and property assessment and taxation. The Borough is also the primary provider of education, housing, utilities, employment and other basic services to residents of North Slope villages.

Local governments in the NANA region have very limited tax bases and thus are limited in their resources and powers. They are supplemented by a variety of regional, federal and state organizations that provide community facilities and services for such functions as education, transportation, health and social services, housing, manpower development and coastal management.

Recreation

There is little published information on recreational use of the project area. Most of the data presented in this study were collected by: interviews with area residents; personal communication with guides, charter services and resource personnel; and review of agency files and survey records. The area of study is generally contained within Game Management Unit 23, which is "...that area drained by all streams flowing into the Arctic Ocean and Kotzebue Sound from Cape Lisburne on the north to, and including, the drainage into Goodhope River on the south" (ADF&G, 1981). Since many recreational activities occur primarily within the National Park system, the primary study area is defined as the western portion of the Noatak Preserve, the northern portion of Cape Krusenstern National Monument, and those portions of Unit 23 in the vicinity of the proposed project.

The recreational activities under study include hiking, flying, boating, hunting, fishing, winter sports and sightseeing. However, local residents pursue many of these same activities for a livelihood. It is therefore necessary to distinguish between recreational use and subsistence use of local resources. For purposes of this document, recreational activities are defined as those outdoor activities pursued by non-residents of the region.

Recreational opportunities in the study area are somewhat limited compared to other areas of the state. The restricted and costly access, the lack of support facilities, the fairly flat, wet terrain, long harsh winters and short summers have kept recreational use to a minimum. In fact, non-resident winter sport activities such as dogsledding, snowmobiling and skiing virtually do not exist. Recreational flying was also determined to be almost nonexistent. It is estimated that from 250 to 350 non-residents engaged in recreational activities in the primary study area in 1982 (Cominco Alaska, Inc., 1983b).

People that do visit the area generally engage in a variety of activities, and it is often difficult to differentiate between individuals who come for such diverse purposes as wildlife viewing, photography, archeology, ecological observation and backpacking. However, because boating or rafting is the usual means of travel in the study area outside Cape Krusenstern, it is convenient to use boating as the recreational activity common to all such visitors. Other major recreational use includes hunting, fishing and visiting Cape Krusenstern National Monument. Again, it is not unusual for visitors to engage in more than one activity, for example, sport fishing while on a boating trip.

Boating

The Noatak River accommodates the greatest number of boaters using the primary study area. Data collected from area guides and air taxi services suggest that up to 200 non-residents may utilize the Noatak for recreational boating each year. Most boaters disembark before leaving the Noatak National Preserve; the rest continue on the river to the village of Noatak. Few boaters continue beyond the village because of the usual high winds over the flats.

Boaters commonly take a chartered plane from Kotzebue, Ambler or Bettles to a gravel bar landing site on one of the Noatak River tributaries. For approximately $1,600 per person, a licensed guide will provide a 14-day trip with all gear included. Sport fishing is allowed, and with proper licensing, sport hunting is allowed within the Noatak Preserve.

Hunting/Fishing

Non-resident participation is often limited to professionally guided hunting and fishing trips. Licensed guides use the project area primarily for hunting sheep, bear, moose and caribou; and for Arctic char, Arctic grayling and chum salmon fishing. Approximately 150 people were flown into the area in 1982, fishermen outnumbering hunters two to one. Costs for guided trips range from $700 a day for fishing up to an average of $4,800 for a single game hunt. Some local residents hunt and fish for recreation, and cabin and tent camp facilities also exist in the area.

ADF&G data for Game Management Unit 23 show total harvests of 680 caribou in 1981-82 and 1,038 caribou in 1982-83 (Ott, 1983). The large majority of these is taken by residents. However, game biologists estimated that up to 4,000 caribou may actually have been harvested from Unit 23 (Cominco Alaska, Inc., 1983b). This discrepancy between reported and probable caribou harvesting indicates that game harvest records probably do not accurately represent the take. Additional ADF&G data reported between 1962 and 1981 show the total average annual game harvest included 17 Dall sheep and 23 bear. Moose harvest records are incomplete for Unit 23, but three years of data show a yearly average of 71 moose taken from the Noatak, Kobuk, Kukpuk, Kivalina and Wulik River areas. ADF&G records from 1982 show a total fish harvest of about 2,060 from the Noatak, 2,840 from the Kobuk, 805 from the Wulik and 3,660 from all other rivers in Unit 23. It is often difficult to distinguish between recreational harvest and subsistence harvest, so harvest data may not accurately reflect type of use. It is evident however, that a great deal of resident hunting and fishing takes place, and that subsistence use greatly exceeds recreational activities (Cominco Alaska, Inc., 1983b).

Cape Krusenstern National Monument

Cape Krusenstern National Monument was established, and is to be managed, for the following purposes:

- To protect and interpret a series of archeological sites that depict every known cultural period in Arctic Alaska.
- To provide for scientific study of the process of human population of the area from the Asian continent.
- To preserve and interpret evidence of prehistoric and historic Native cultures.
- To protect habitat for seals and other marine animals.
- To protect habitat for, and populations of, caribou herds and other wildlife, and fish resources.
- To protect the viability of subsistence resources.

Park Service statistics estimate 1982 Cape Krusenstern users at 10,200 people. This number was derived by noting snowmobile and three-wheel vehicle tracks, periodic aerial surveys, reviewing camp records and conducting personal interviews. However, since the winter trail between Kotzebue and Kivalina passes through Cape Krusenstern, this number is assumed to reflect largely resident traffic. Local residents and air taxi service personnel indicated that few, if any, non-residents visit Cape Krusenstern for recreational purposes as there are no rivers adequate for boating and sport hunting is not allowed. NPS representatives estimate that only two percent of users currently visit the Monument for recreational purposes (Shaver, personal communication).

V. ENVIRONMENTAL CONSEQUENCES

INTRODUCTION

This section contains the scientific and analytical basis for the comparison of project alternatives. Potential impacts of the components which are common to all alternatives, and therefore not dependent upon selection of a particular alternative are discussed first on a discipline by discipline basis. Beginning on page V-36, the impacts of each project alternative are discussed on a discipline by discipline basis where certain components differ for each alternative.

Since for almost all disciplines the impact of the No Action Alternative would be the status quo, impacts of the No Action Alternative are not discussed for each of the individual disciplines. Rather, the No Action Alternative is discussed in a separate section which deals primarily with the socioeconomic impacts of no project implementation. The No Action Alternative would result from denial of at least one of the permits necessary for project development, or it could result if the project sponsor chose not to undertake the project.

Potential project impacts on each discipline have been quantified where possible. Qualitative descriptions of effects are provided to identify differences in magnitude, significance or duration among alternatives. Unless noted differently, the discipline criteria which were used to initially screen project options, as discussed in Chapter III (Table III-5), are the same criteria that were used to evaluate the impacts of project components on each discipline.

Throughout the individual discipline analyses references are made to mitigation, monitoring and reclamation measures. The impacts discussed for a given discipline assume implementation of those specific measures. Later in this chapter all mitigation, monitoring and reclamation measures are briefly summarized.

COMPONENTS COMMON TO ALL ALTERNATIVES

Eight components of the project are common to each alternative: the mine location, the tailings pond in the South Fork of Red Dog Creek, South Fork mill site, South Fork location for worker housing, a campsite housing type, Bons Creek water supply reservoir, diesel power generation and year-round road. With the exception of the year-round road, these common components are discussed here together in a separate section because they are not dependent upon selection of the Preferred Alternative. They were not open to alternative development either because their locations would be fixed (e.g., the mine location), or because they clearly represented the best option for that component. As it would not be logical to discuss the consequences of the road unless it was tied to a specific location, the environmental consequences of the year-round road are discussed later in conjunction with the location of the transportation corridor as a component specific to some alternatives. The Component Specific to Some Alternatives section (p. V-36) discusses environmental consequences of the three components that differ for each alternative, i.e., the transportation corridor location, the port site location and the marine transfer facilities.

Vegetation and Wetlands

The mine area facilities (mine and overburden storage area, tailings pond, mill site, worker housing, water supply, airstrip and all associated access roads) would directly disturb a total of approximately 541 ha (1,336 ac) in Red Dog Valley. The mine, overburden storage area and supporting access road system would eventually eliminate a total of approximately 235 ha (580 ac) of ground cover, including 152 ha (375 ac) of dwarf shrub tundra and 83 ha (205 ac) of low shrub tundra. The tailings pond would cover approximately 237 ha (585 ac), including 68 ha (168 ac) of low shrub tundra, 62 ha (152 ac) of dwarf shrub tundra and 107 ha (265 ac) of sedge-grass tundra. Depending on the final contour, an additional 8 ha (20 ac) of open low shrubland may also be disturbed.

Construction of the mill site, worker housing structures and the access road between the two would directly disturb 26 ha (65 ac) of sedge-grass tundra. The Bons Creek water supply reservoir and access road would disturb about 31 ha (76 ac) of dwarf shrub (mat and cushion) tundra. The airstrip and associated service roads would disturb about 12 ha (30 ac), including 6 ha (15 ac) of dwarf shrub tundra, 2 ha (6 ac) of open low shrubland and 4 ha (9 ac) of sedge-grass tundra.

Because of the considerable amount of human activity associated with a large scale mining operation, disturbance from foot traffic, off-road vehicle traffic and dust may affect additional acreage of vegetation in Red Dog Valley. Sensitive plants such as lichen species may exhibit a loss of vigor caused by pollutants emitted at the mine site. There might also be a loss caused by pollution from metal sulfides in dust mobilized in the mining and transport of ore. Some elements (e.g. lead) might bioaccumulate in plant tissues (Olson, 1982). Communities adjacent to access roads would be contaminated by any fuel, chemical or concentrate spill. The degree of impact would depend on the nature of the site and spill, time of year and cleanup procedures (Brown et al., 1980). The following vegetation types could be indirectly affected by the project: low shrub tundra; open low shrubland; dwarf shrub tundra; and sedge-grass tundra. The total vegetation and wetland loss however, would not be significant on more than a local basis.

Wetlands in the mine area include sedge-grass tundra and open low shrub communities. Regulation of wetlands in most of the area would be covered under a Nationwide 404 Permit, pending water quality certification by DEC (see Appendix 5, Section 404(b)(1) Evaluation). The nationwide permit would not be valid for the tailings pond dam or for the road from the mine pit to the dam. These discharges of dredged or fill material would be included in the DA permit review.

Terrestrial Wildlife

The discussion below primarily addresses four impacts upon major wildlife species or groups: first, direct habitat loss, which is the actual physical destruction of habitat; second, indirect habitat loss, which is the effective loss of habitat use because of noise, human contact or other disturbance directly associated with project construction and operation; third, the effects on animal movements; and fourth, construction impacts. A fifth wildlife impact, long-term increased public access to the project area, is discussed separately in a general manner under "Other Project Impacts" later in this chapter. It is also described more specifically here for components where increased access impacts would likely be of major significance.

Direct habitat loss from construction of the mine area facilities would total approximately 541 ha (1,336 ac). On a local basis this loss could be significant for song bird and small mammal species, but it would not be significant on a greater than local basis. For other wildlife such as birds of prey or larger mammal species, direct habitat loss would not be significant even on a local basis.

Indirect habitat loss, however, could be significant on a greater than local basis. While local song bird and small mammal populations would likely accommodate to the presence of the facilities and associated activities, birds of prey and larger mammals would generally tend to avoid the area. The degree of avoidance cannot be accurately predicted.

At least two inactive golden eagle nests were identified within the South Fork Valley (Dames & Moore, 1983b), and other raptor nests might exist. Both nests are within 1.6 km (1 mi) of proposed mine area facilities and birds attempting to breed there would probably be affected by activities associated with construction and operation of the project. This disturbance would likely cause abandonment of the nests. The valley might also serve as hunting territory for other birds nesting outside the valley, thus indirectly limiting their habitat use of the area.

The South Fork Valley is generally to the northeast of the currently used caribou wintering grounds in the lower Kivalina and Wulik drainages. This area was not used by caribou during the 1981-82 or 1982-83 winters (Dames & Moore, 1983a). However, caribou are capricious animals and the valley may have been used many times in the past. Thus, development and operation of mine facilities in the South Fork Valley might have an indirect impact upon caribou by displacing a few animals from this area during winter. The major portion of the annual post-calving migration in July appears to pass just to the northwest of Red Dog Valley and would probably not be significantly affected by mine area development. However, some animals would likely have to alter their movements to avoid the valley.

Bears, wolves, wolverines and foxes would also be impacted by disturbance and human contacts. While not significant on a greater than local basis, individuals would be displaced from the general area unless attracted by improper disposal of garbage or outright feeding. To minimize such attraction, garbage collection sites and incinerators would be fenced using adequately high, deep and strong Cyclone-type "bear proof" fencing, and workers involved with garbage disposal would be instructed in proper collection, handling and incineration techniques. Incinerator wastes and unburnable solid wastes would be buried in the tailings pond to eliminate landfills and their associated wildlife attraction problems.

Feeding of animals would be prohibited and this would be strictly enforced. The ADF&G regulation prohibiting such feeding (5 AAC 81.218) would be posted conspicuously throughout the camp. All workers would receive environmental training which would stress the importance of this prohibition, the usual consequences to the animals themselves from being fed, and the potential danger to employees (e.g., bear/human contacts, rabid foxes). These safeguards of proper garbage handling, fencing, feeding prohibition and worker environmental training would: increase worker safety by reducing exposure to bears, foxes and other carnivores; reduce worker/carnivore contacts that would detract from job performance; and reduce the time, effort and expense for the applicant and/or ADF&G to trap, immoblize and relocate nuisance animals, or to kill animals in defense of life or property.

The mine area facilities appear to be near the southern limit of present Dall sheep range in the De Long Mountains. However, a group of five ewes and lambs was reported in the South Fork Valley in June 1982 (Dames & Moore, 1983a). Development in the valley would initially displace most sheep activity in the vicinity. In time, depending upon human contacts in their primary mountain habitats, sheep might adjust to the project.

Indirect habitat loss in the South Fork Valley would not be significant for moose, muskoxen or waterfowl.

Construction activities, aside from direct habitat loss, would have relatively little impact upon song bird or small mammal species. They would displace larger mammals to a greater degree than during operation of the facilities. This would probably not be of greater than local significance, except possibly for caribou.

Groundwater Resources

Project impacts related to groundwater concerns can be generally inferred from established theories of groundwater movement in Arctic regions. Groundwater movement in the project area is restricted by the presence of permafrost and tightly bedded shales. Movement becomes significant only in thawed substrate such as that found in thaw bulbs under stream surfaces and in the active layer above permafrost during the summer. Groundwater concerns can be related to design of the ore zone runoff collection ditch; collection of seepage from the tailings pond; and containment of fuel and/or chemical spills in the vicinity of the mill site.

To control sediment, a diversion ditch, possibly lined with plastic, would be constructed between the ore zone and the main stem of Red Dog Creek. In addition to its specific purpose of controlling sediment, the ditch would likely intercept much of the natural ore zone seepage presently entering the creek. If this were to occur, it would be reasonable to assume that mining activities would improve existing water quality conditions in the main stem of Red Dog Creek and downstream.

Some potential exists for seepage from the tailings pond through the abutments or foundation of the dam embankment. Although the highly fractured shale is currently impermeable due to ice-filled fractures, permeability and resultant seepage rates might increase should these fractures thaw during construction and operation of the pond. A seepage control facility would be included as part of the tailings pond embankment construction and would largely eliminate the risk of seepage entering Red Dog Creek. Any seepage intercepted would be pumped back into the tailings pond.

Fuel or chemical spills would pose a high risk for groundwater contamination because of the shallow water table depth in the project area. Although groundwater resources are not significant, soils containing groundwater serve as conduits for contaminant migration to nearby streams. The travel time between a spill site and nearby streams would depend on the depth of the thawed layer, soil permeability, hydraulic gradient and travel distance. Significant spills could cause surface water contamination within days or weeks following the spill occurrence. However, the most likely location for potential spills would be in the tailings pond drainage area where no risk would exist to streams. The Spill Prevention Control and Countermeasure (SPCC) Plan (Appendix 2) would limit impacts of spills both there and in other areas.

It should be noted that because of the presence of permafrost at shallow depths, potential groundwater contamination likely would occur only in the active thaw layer and would not impact deeper aquifers as could occur in nonpermafrost areas.

Freshwater Resources

Hydrology and Water Quality

A description of the water balance of the tailings pond was required to determine the quantity and quality of water that would enter the tailings pond so that pond capacity and treatment requirements could be established. The average annual water balance for the tailings pond is shown in Table V-1.

Water quality data for the main stem of Red Dog Creek above South Fork were analyzed to determine the loads of toxic metals coming from the ore zone. The analysis was done for the toxic metals zinc, lead and cadmium which would be of primary concern. Ninety-five percent of the metal loads in the main stem above South Fork come from the area bounded by the exposed ore zone. A diversion ditch would be constructed between Red Dog Creek and the open pit to collect runoff from the mine area. Since approximately 10 percent of the area of exposed ore occurs across the creek from the proposed diversion ditch, the ditch would have the potential to intercept about 85 percent of the total toxic metal loads. This would represent a 75 percent reduction of zinc, lead and cadmium loads reaching Ikalukrok Creek.

Table V-1

TAILINGS POND WATER BALANCE

Source	Initial Production Phase		Expanded Production Phase	
	ℓ/min	gal/min	ℓ/min	gal/min
Surface runoff and net precipitation on pond	6,529	1,725	6,529	1,725
Net mill discharge to pond	878	232	1,514	400
Mine drainage pumped to pond	594	157	1,188	314
Water trapped in tailings	314	83	655	173
Volume of water displaced by dry tailings	450	119	946	250
Free water on top of tailings	7,687	2,031	8,577	2,266
Volume of tailings and water after treatment	1,014	268	1,805	477
Treated water (annual average)	7,123	1,882	7,718	2,039
May to October discharge (six months)	14,246	3,764	15,436	4,078

If the diversion ditch were fully effective at collecting the ore zone runoff, it would annually divert 54 Mg (60 tons) of zinc, 1.8 Mg (2 tons) of lead and 0.4 Mg (0.5 ton) of cadmium to the tailings pond during the initial phase of production. This would represent an annual flow of 594 ℓ/min (157 gal/min) of water containing 87 mg/ℓ of zinc, 3 mg/ℓ of lead and 0.8 mg/ℓ of cadmium to the pond. Although the ditch might not be completely effective at diverting these toxic metal loads initially, eventually the open pit would reach across Red Dog Creek, and the entire stream would be diverted around the open pit or isolated from ore contact during mine operation. With this diversion, a 95 percent reduction in toxic metal loads to Red Dog Creek above the South Fork might be attained. A monitoring program on Red Dog Creek at its mouth would allow determination of improvements in water quality as the open pit enlarged.

The drainage area to the tailings pond would be 7.12 km^2 (2.75 mi^2). Approximately 1.8 km^2 (0.7 mi^2) of drainage would be diverted to Bons

Creek to avoid having to treat additional clean water and to replace water removed from the Bons Creek water supply reservoir. The tailings pond water surface area would eventually reach 2.6 km^2 (1.0 mi^2). Precipitation over the drainage area would be 64 to 71 cm/yr (25 to 28 in/yr). Evaporation from either water or land would be 15 to 23 cm/yr (6 to 9 in/yr). Net runoff would be 48 cm (19 in) or 0.015 $m^3/s/km^2$ (1.4 $ft^3/s/mi^2$) or 6,529 ℓ/min (1,725 gal/min).

EPA regulations issued in December of 1982 established discharge limitation New Source Performance Standards (NSPS) for ore mining and processing facilities (40 CFR 440). The standards that specifically apply to the Red Dog facility include no discharge of process (mill) wastewater, restriction of discharge to net precipitation over evaporation from the mine and mill areas during the mine life, and limitations on mine drainage. Specific requirements for metals and other parameters in discharged waters also apply (Table V-2).

The allowable discharge (net precipitation) is determined for an annual volume of precipitation and evaporation, not the excess that may occur over a few days or weeks. Short-term excesses would be handled by the free board of the facility. Both precipitation and evaporation vary from year to

Table V-2

TREATED WATER QUALITY PROJECTIONS

Parameter	Typical Case (mg/ℓ)	Worst Case (mg/ℓ)	1 Day EPA Standard[1] (mg/ℓ)	30-Day EPA Standard[1] (mg/ℓ)
Zinc (Zn)	0.86	1.87	1.50	0.75
Lead (Pb)	0.010	0.015	0.600	0.300
Cadmium (Cd)	0.020	0.020	0.100	0.050
Copper (Cu)	<0.015	<0.015	0.300	0.150
Mercury (Hg)	<0.00005	<0.00005	0.002	0.001
Total suspended solids (TSS)	4.6	4.5	30.0	20.0
pH (units)	10.5	10.5	6.0 to 9.0	6.0 to 9.0

[1] EPA Standards from 40 CFR 440.104(a) Mine Drainage Standards.

year. Normal average precipitation and evaporation are used in determining net precipitation at a facility. Additional discharge would be allowed to account for wet years and heavy snow packs. The volume of annual net precipitation would be discharged so that daily discharge volume over the discharge season would equal the total annual volume of excess precipitation.

At the Red Dog project, as previously discussed, some water would be imported into the basin for process uses. Of this imported water a portion would be tied up in voids of the settled tailings. The remaining portion would be water that cannot be discharged in accordance with the EPA net precipitation regulations. This would amount to an equivalent of 563 ℓ/min (149 gal/min) accumulation in the tailings pond. Reclamation of the tailings pond would not be possible unless dewatering could occur. Interpretations by EPA indicate that the tailings pond could be dewatered through the treatment plant after the mining operations were permanently closed. This would be regulated by a separate NPDES permit. Present regulations would result in an accumulation of water during the mine life.

Net mill discharge to the tailings pond would include 45 ℓ/min (12 gal/min) of domestic wastewater. This wastewater would effectively be treated by conditions in the tailings pond. Bacteria levels in the pond would not be significant since dilution, toxic metal concentrations and low pH would lead to rapid bacteria die-off.

During the initial five years of production, approximately 1,496 Mg/day (1,650 tons/day) (dry weight) of tailings would enter the tailings pond. This would increase to 3,129 Mg/day (3,450 tons/day) during the expanded phase of production. The wet tailings would have 60 percent solids by weight, which would reduce to 70 percent solids by weight after settling in the pond.

The tailings pond would be built in stages, with the maximum sized dam constructed by the fifth year of production. Maximum dam elevation would be 289 m (950 ft) with the spillway at 288 m (944.6 ft). Staging of dam construction would allow for the accumulated volume of dry tailings, water trapped in tailings voids, inflows in excess of natural runoff, and the 10-year recurrence 24-hour storm runoff event. A 1.5 m (5 ft) freeboard would be maintained to prevent overtopping during the probable maximum flood.

The Red Dog mine plan schedule for construction of the tailings dam in stages would consider the influence of wet years. During the five-year construction period, because of the limited capacity of the tailings pond, there would be a significant risk that if a 50-year recurrence wet year occurred, the dam might be overtopped. To prevent this, adequate capacity would be maintained during the construction period to contain this event. Probability analysis of Kotzebue annual precipitation data indicated that a 50-year recurrence would be approximately 1.8 times the annual mean. Precipitation in the project area (mean annual 64 cm [25 in]) would therefore have a 50-year recurrence of 114 cm (45 in). Capacity to handle an additional 51 cm (20 in) of runoff would be maintained in the pond at the beginning of each runoff season (May). Treatment rates would be increased when it became obvious that an unusually wet year (50-year recurrence interval or greater) was in progress, and treatment would continue, if necessary, into winter months until the extra runoff was treated. The increased discharge of treated effluent and spring melt of accumulated icings would further improve the water quality of Red Dog Creek compared to an average year.

The 10-year recurrence 24-hour storm event at Red Dog Valley would be at least 10 cm (4 in). This value was derived by using the ratio of annual precipitation at Red Dog Valley (51 to 64 cm [20 to 25 in]) to annual precipitation at Kotzebue (21 cm [8.4 in]) in order to adjust the Kotzebue 10-year 24-hour storm event which was 4.3 cm (1.7 in).

Natural inflows (South Fork and ore zone runoff) to the tailings pond (7,114 ℓ/min [1,882 gal/min]) would mix with the mill discharge and be treated before discharge to Red Dog Creek. Discharge would occur during the six-month period from May to October when the creek would be unfrozen. Any discharge of treated water during winter months would not be expected to be of environmental concern as long as the icing accumulation would completely melt in spring and summer. The discharge point would be on the main stem of Red Dog Creek 19 m (62 ft) below the confluence with the South Fork. The average annual treated water discharge over that six-month period would be 14,246 ℓ/min (3,764 gal/min) or 0.23 m^3/s (8.4 ft^3/s). The treatment facility would be designed to handle greater treatment rates during wet years.

The High Density Sludge (HDS) process would be used to remove toxic metals from the tailings pond water. The process would use lime treatment to precipitate metals as hydroxides, and then increase the densities of the precipitated hydroxides to give a sludge with good handling and filtration characteristics. The process plant would draw feed water from the pond, discharge a clean effluent to Red Dog Creek and recover the sludge.

In order to design the treatment process, the predicted water quality of the tailings pond water was forecast. Table V-3 shows typical and projected worst case scenarios of anticipated tailings pond water quality as calculated from baseline water quality data (Dames & Moore, 1983a).

Other chemicals used in the milling process may be present in tailings pond water. Most flotation process suppressant reagents would remain with the tailings and would settle in the tailings pond. Flotation aids would remain with the ore concentrate. However, small fractions might accumulate in the tailings pond water and might impact treatment plant design. Projected concentrations of the toxic process chemicals are shown below:

	Typical Case (mg/ℓ)	Worst Case (mg/ℓ)
Free Cyanide (CN^{-1})	0.01	0.03
Total Cyanide	0.02	0.05
Xanthate	0.005	0.01

These chemicals are oxidized in the presence of sunlight, decompose, or form complexes in conditions that would be prevalent in the tailings pond. They

Table V-3

TAILINGS POND WATER QUALITY PROJECTIONS
(Assuming Complete Mixing)

Parameter	Typical Case (mg/ℓ)	Worst Case (mg/ℓ)
Zinc (Zn)	238.0	586.0
Lead (Pb)	1.2	1.3
Cadmium (Cd)	2.2	4.0
Calcium (Ca)	54.0	70.0
Manganese (Mn)	13.7	17.8
Magnesium (Mg)	15.1	19.4
Iron (Fe)	2.3	2.8
Barium (Ba)	0.1	0.4
Aluminum (Al)	0.4	0.7
Copper (Cu)	0.1	0.1
Mercury (Hg)	0.002	0.002
pH (units)	4.0	4.0

should, therefore, not present an impact. Treatment plant design would be modified if necessary to reduce effluent concentrations of these chemical parameters to non-toxic levels.

Pilot testing was used to estimate the efficiency of the treatment process (Cominco Engineering Services, Ltd., 1983a). Typical and worst case scenarios of water quality concentrations of the treated effluent are compared to EPA effluent standards in Table V-2.

The treatment process would work most efficiently at pH 10.5. This would be higher than the EPA pH limitation of 9.0. However, since the natural surface waters would usually be slightly acidic, a basic effluent discharge of pH 10.5 should serve as a buffer and might ameliorate conditions downstream. In the worst case test zinc would be the only metal which would not satisfy EPA regulations for mine discharge. The high concentrations predicted result from high zinc concentrations in the total suspended solids (TSS) remaining in the effluent after treatment. In actual practice, effluent might contain lower TSS levels or additional dilution water so zinc levels might be more closely in compliance with EPA standards. The projected worst case zinc concentration of 1.87 mg/ℓ would still represent a substantial improvement over natural conditions (6 to 19 mg/ℓ).

Zinc found in pilot test work was mostly in the form of a finely divided precipitate that was not removed totally by conventional settling. Laboratory tests using filtered test effluent indicated the soluble portion (non-filterable) was projected to be less than 0.15 mg/ℓ.

In many tailings pond environments, additional surface runoff dilution, aging, mixing of pond water, and other conditions that cannot be fully simulated result in treatment plant operations different from laboratory results. The full scale operation of the tailings pond water treatment facility would allow optimization of the treatment process. The tailings impoundment would not fill during the first years of operation, so the operators would have sufficient time to operate the treatment plant in a closed loop (discharging back to the tailings pond) until the process performance was proven. If in actual on-site, full scale treatment tests clarification could not remove zinc to acceptable concentrations, other unit processes such as filtration could be added to assure compliance with EPA standards.

Anticipated effluent water quality compared to pre-mining seasonally occurring water quality in Red Dog Creek above South Fork is shown below:

Parameter	Effluent (mg/ℓ)	Red Dog Creek (mg/ℓ)
Zinc (Zn)	0.75 to 1.50	6.0 to 19.0
Lead (Pb)	0.010 to 0.015	0.1 to 0.5
Cadmium (Cd)	0.02	0.05 to 0.14

A comparison of anticipated total annual loads to Red Dog Creek before and during mining is shown below for downstream of the confluence of South Fork with the main stem of Red Dog Creek:

	Pre-mining Condition		During Mining Operations	
Parameter	Mg/yr	tons/yr	Mg/yr	tons/yr
Zinc (Zn)	66.21	73.00	10.6 to 12.0	11.8 to 13.3
Lead (Pb)	2.36	2.60	0.35 to 0.36	0.39 to 0.40
Cadmium (Cd)	0.77	0.85	0.24 to 0.48	0.27 to 0.53

These anticipated figures show that lead and zinc loads would be reduced by approximately 80 percent and cadmium loads by 50 percent. Corresponding reductions in Ikalukrok Creek would be 75 percent for lead and zinc and 45 percent for cadmium. Water quality in Red Dog Creek and Ikalukrok Creek could, therefore, be significantly improved.

Since the treated effluent would be steadily discharged during a six-month period between May and October (no winter discharge), flows in Red Dog Creek below the South Fork confluence would change somewhat compared to natural seasonal conditions as shown below:

	Natural Condition		During Mining Operations	
Season	m^3/s	ft^3/s	m^3/s	ft^3/s
Summer low	0.31	11.0	0.48	17.0
Storm events	1.42	50.0	1.13	40.0
Winter	0.03	1.0	0.03	1.0
Spring	1.13	40.0	0.99	35.0

The most significant changes to flow would occur during low flow periods in summer. During drought conditions the treated effluent could represent 60 to 75 percent of the flow in Red Dog Creek at the point of discharge below the South Fork. Flows in Ikalukrok Creek below Red Dog Creek would have corresponding treated effluent proportions of seven to 10 percent. This flow increase would be expected to improve water quality in Ikalukrok Creek.

Overflows of untreated tailings pond water would occur only in the highly unlikely combination of the following events:

- a wet year with a recurrence interval over 50 years;
- during the first five years of construction or the last year of operation;
- during a runoff event of sufficient magnitude to also fill capacity allocated to the 10-year, 24-hour storm;
- and when inflow to the tailings pond exceeded the emergency treatment capacity of the treatment plant (0.57 m^3/s [20 ft^3/s]).

Dilution of such an overflow would occur from simultaneous natural flood flows in Red Dog and Ikalukrok Creeks. These natural flood flows would reduce concentrations of lead, cadmium and TSS to levels below normal natural flow conditions. The only significant concentration that would exceed normal natural flow conditions would be zinc. The concentration of zinc in tailings pond overflow water, after dilution due to precipitation and local runoff, would approximate 100 mg/ℓ. Based on a real runoff proportion, dilution of an overflow by the time it reached the mouth of Red Dog Creek would be nine to one. However, actual dilution would be much greater since the overflow would be reduced by the emergency capacity of the treatment plant. The highest possible zinc concentration at the mouth of

Red Dog Creek would therefore be less than 11 mg/ℓ. The maximum observed zinc concentration at the mouth of Red Dog Creek was 5.0 mg/ℓ (Dames and Moore, 1983a). However, higher winter concentrations at the mouth were known to exist based on upstream measurements.

At the mill site, spill hazards would exist from the storage and use of mill process chemicals and oil. Spillage control plans and rapid response to spills would be the primary mitigative measures utilized. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

If the dam foundation were to thaw there would be a potential for dam seepage through cracks and fissures in the foundation rock. A seepage containment dam and pumpback system would be installed downstream of the dam to pump back any seepage to the tailings pond without significant impact.

To protect the water quality of streams during construction, an erosion and sediment control plan would be followed. This plan would describe procedures for removal of tundra vegetation, topsoil stockpiling and reestablishment of vegetation on cleared areas. Sediment would be controlled in cleared areas by sedimentation ponds. These ponds would be constructed in the mill and accommodation areas, and would be designed to retain runoff from a 10-year recurrence 24-hour storm event. After construction was completed, runoff would be directed to the tailings pond.

Water quality protection in the vicinity of the worker accommodations, airstrip and access roads would require control of sediment during construction, and revegetation of disturbed areas as soon as possible after construction was completed. Spill hazard control procedures for these areas are described in the SPCC Plan (Appendix 2).

The Bons Creek water supply would be used for mill operations, domestic purposes and for dust suppression. Since 1.8 km^2 (0.7 mi^2) of the South Fork drainage would be directed to Bons Creek, this drainage would have a net gain in water. An annual average of 1,703 ℓ/min (450 gal/min) would be directed to Bons Creek via diversion ditches and 1,136 ℓ/min (300 gal/min) would be pumped back for use in mine operations. Flows in Bons Creek below the reservoir would be reduced during low flow periods and increased during high flow periods. Reductions to flow in Dudd Creek where it enters Ikalukrok Creek would be approximately two percent during low flow periods. There would be no significant changes to water quality.

Biology

Invertebrates

Operation of the mine and tailings pond is expected to decrease the naturally occurring metals content of Red Dog Creek. Depending on the amount of metals reduced, the chemical speciation of the remaining metals, and the concentration of residual metals from past deposition, benthic production could increase in the main stem of the creek. Sensitive taxonomic groups presently absent from the most degraded areas (Nematoda, Neptageniidae, Tubificidae and Ostracoda) could return, and presently depressed numbers increase. However, this potential increase in benthic production would probably not have a significant beneficial impact on Ikalukrok Creek fisheries because of the offsetting loss of benthic habitat from the South Fork of Red Dog Creek.

Construction of the tailings pond in South Fork Valley would remove 83 percent of the creek, or approximately 5.3 km (3.3 mi) of clear water, gravel-bottomed stream habitat. Benthic macroinvertebrate production is moderate in this stream, with densities approximately half of those found in the most productive streams of the project area (Dames & Moore, 1983a). While the removal of this stream section would represent a significant benthic habitat loss to the entire Red Dog Creek system (12 percent), direct impacts to downstream fish species in terms of reduced food availability are negligible. Closer and more productive drift food sources in the North Fork of Red Dog Creek and Ikalukrok Creek should not be affected by the South Fork tailings pond.

Construction of a water supply reservoir on Bons Creek would result in temporary decreases in the downstream benthic productivity of Dudd Creek due to altered stream flows and increased sedimentation. Flow changes may affect overall productivity in Dudd Creek, but should not result in any significant changes in Ikalukrok Creek fisheries. Bons Creek presently contributes a relatively small portion of the total Ikalukrok Creek system flow.

During the construction of mine area facilities, sediment loads may increase in Red Dog Valley streams. If care were taken to control or treat erosion with diversion ditches, sedimentation basins and revegetation techniques, construction impacts would be minimal and transitory. However, if erosion were not controlled, benthic productivity would decrease, especially in clear water streams (tributaries of the South Fork and main stem of Red Dog Creek) located adjacent to project components.

Fish

Currently Red Dog Creek, and perhaps part of Ikalukrok Creek below the confluence of Red Dog Creek, are toxic to fish at most times of the year. Toxic metal loadings to Red Dog Creek would decrease as a result of diversion ditch construction at the mine and water treatment. The combination of a possible significant improvement of water quality in Red Dog Creek, and the potential that a chemical barrier currently exists in Ikalukrok Creek, could lead to the utilization of the upper Ikalukrok Creek by char and salmon, as well as utilization of Red Dog Creek by grayling, char and salmon. This has raised the concern for both Red Dog Creek and Ikalukrok Creek that metal accumulation in fish tissue could increase and thereby affect humans consuming these fish.

Baseline studies indicate that even with high metal loadings occurring at the present time, only cadmium, zinc and copper accumulate in fish tissue. With decreased metal loadings expected, it would be highly unlikely for other metals to emerge as fish tissue contaminants. This is because in the lower metal loadings scenario predicted, natural metal chelation* and precipitation mechanisms would occur as they do now, but closer to the source. These chelation and precipitation mechanisms are currently overloaded in Red Dog

---

* Defined in Glossary.

Creek and at the present time occur over a relatively short distance in Ikalukrok Creek. Long-term exposure of fish to waters with low metal concentration levels currently exists in Ikalukrok Creek downstream of Red Dog Creek, and only small metal accumulations in fish tissues have been found. Further, cadmium, zinc and copper vary seasonally in tissue concentration, which indicates that metals excretion occurs when fish are not directly exposed to metals (i.e., during migration or other movements away from the metal source). This same migration or movement phenomenon would occur in the mining situation and should not allow increased accumulation of any of the three metals.

Presently, no guidelines exist which set dangerous levels for zinc, copper or cadmium in fish tissues used for human consumption. Zinc and copper are essential trace elements for humans, whereas cadmium is considered a toxic chemical to humans. Cadmium would have to be ingested at a rate of 350 μg/day for 50 years to reach a critical poisoning level (Reeder et al., 1979). Based on the highest fish tissue levels of cadmium reported in the baseline study, a person would have to daily ingest 6.4 kg (14.1 lb) wet weight (1.1 kg [2.4 lb] dry weight) of the muscle tissue of char for cadmium poisoning to occur in 50 years. Based on the average tissue levels found in the study, a person would have to daily ingest over 11.6 kg (25 lb) wet weight (2.0 kg [4.5 lb] dry weight) of char for 50 years before critical levels were reached. These high consumption rates, especially considering the seasonal usage of these fish, clearly demonstrate that the normal ingestion of fish containing small amounts of cadmium should not be of concern.

Initial development of the mine site would include establishment of collection ditches, preproduction stripping and road construction. Blasting activities, initial stripping and road construction should not impact Red Dog Creek. Collection ditches and berms would be constructed quickly so that suspended solids escaping to Red Dog Creek would be low. The effect of any increase of small suspended solids on fish should not be detectable.

Eventual diversion of the main stem of Red Dog Creek around the ore body would be expected to cause increased suspended solids loadings during construction and upon initiation of discharge in the new channel. This increase would be unavoidable and might cause some short-term downstream impacts on fish. Suspended solids loading during construction and initiation of discharge in the new channel would be analogous to suspended solids associated with a major storm event. Any effects would be felt primarily within Red Dog Creek with limited amounts of fine sediment reaching Ikalukrok Creek. Increased suspended solids loadings from this source subsequent to stabilization should only occur during the first subsequent annual high flow periods and should not cause undue stress to fish populations.

Reclamation of all disturbed areas should occur as soon as practicable after the completion of construction activities. This procedure would aid substantially in the reduction of suspended solids loadings to surface waters. Diversion and collection ditches should also undergo some reclamation to assist in erosion control. In addition, it might be necessary to armor or otherwise protect these ditches from erosion.

Operation of the mine, other than the implementation of the creek diversion, should not cause rapid changes in water quality. Surface water collection ditches for the open pit should continue to capture suspended solids. Metals entering Red Dog Creek should diminish over time as ore removal occurred and groundwater flow to the creek was altered.

Post-mining pit reclamation should ensure improved water quality and thus fisheries values. The remaining pit would be flooded to stop further oxidation of low grade mineralization. It is presumed that flooding of the pit would be carried out in a manner that would maintain adequate downstream flow during the period of filling. This approach would protect downstream fish resources.

The tailings pond would be located on the South Fork of Red Dog Creek. No fish have been found in this creek. Construction of the tailings dam would result in some unavoidable increases in suspended solids. These increased loadings should be of short duration. Because of the distance to fish bearing streams and rapid stabilization of disturbed areas, these increased loadings should have limited effects on downstream fish. The diversion of clear water surface runoff to Bons Creek could contribute some sediment to the water supply reservoir, but should be of short duration if proper protection works were employed in the ditches. This should cause no discernible downstream effect in Bons Creek below the pond.

Water leaving the tailings pond would be treated to adequate levels to protect downstream fish resources. In the extreme event when treatment was not possible (as discussed under Hydrology and Water Quality; see page V-12), surface runoff would assist in dilution of tailings pond overflow to prevent or reduce downstream effects on fishery resources.

Alteration of the hydraulic regime in both Bons Creek (and thus Dudd Creek) and Red Dog Creek (and thus Ikalukrok Creek) would be possible. These changes would be minimal in Dudd Creek where low flows would be reduced by two percent and high flows would be slightly increased. These changes would be no more than expected annual variation in stream flow and would not affect downstream fishery resources. Stream flow in Red Dog Creek would be decreased a small amount, but since no fish occur in the main stem of this creek there would be no impact on this aquatic resource. The effects of this small change on the larger Ikalukrok Creek would be small and should not affect this creek's aquatic resources. Instream flow studies have been carried out in both Dudd and Ikalukrok Creeks. Further interpretation of these data could be employed to mitigate any effects of hydraulic changes.

Construction of the mill site and worker housing facilities should have no effect on fish as the facilities would be located away from most streams and drainage would be diverted to the tailings impoundment. The same would be true of the operation and reclamation phases of the mine. The greatest effect on local fish populations would likely be the result of increased fishing pressure from mine employees. This impact could cause significant depletion of local fish populations and probably would require some regulation of sport fishing effort.

Construction and operation of the Bons Creek water supply reservoir should cause minimal hydrologic regime interruption. Fish are not present at or above the reservoir site, so the only expected impact would be some increase in suspended solids during construction of the dam. This impact should be small because of the distance downstream to known fish populations and the short-term nature of the increased suspended solids loadings.

Reclamation of the water supply reservoir might take place upon abandonment, depending on the wishes of the landowner (NANA) and federal and state agencies. Cominco is committed to satisfactory resolution of a reclamation procedure, if necessary, during the life of the mine (see Appendix 1, Reclamation Plan).

Air Quality

Because of its remote location, the project area is designated by EPA as a clean air, or "attainment area", for the pollutants sulfur dioxide (SO_2), nitrogen oxides (NO_x [as NO_2]), carbon monoxide (CO), particulate matter (PM), ozone (O_3) and lead (Pb). This means that the area has attained (i.e., is better than) the National Ambient Air Quality Standards (NAAQS) for these pollutants. The NAAQS are shown in Table V-4. Any project must meet these standards before it can be permitted. The Red Dog mine area facilities would emit all six of these pollutants.

Even if a project would otherwise meet these standards, if any of the individual pollutants would be emitted above certain rates, pollution control equipment qualifying as Best Available Control Technology (BACT) must be installed to minimize that pollutant's emission rate. The EPA Significant Emission Rates are shown in Table V-5.

Potential emissions in Red Dog Valley were analyzed to determine whether any would cause or contribute to pollution in violation of any:

- National Ambient Air Quality Standards (NAAQS); or,
- Prevention of Significant Deterioration (PSD) increment concentrations (SO_2 and PM only).

Major point sources (e.g., power plant) and nonpoint sources (e.g., roads) of emissions in Red Dog Valley would be the mine area, the mill crusher and dryer facilities, and the diesel power plant (Table V-6). Gaseous emissions from the open pit mine would come from diesel-powered equipment such as ore haul trucks, dozers and front-end loaders. The primary source of dust emissions would be from trucks hauling ore from the mine. Other sources of dust emissions would include drilling and blasting operations, ore loading operations, ore and waste rock unloading, and losses from the waste rock stockpile due to wind erosion. Dust particulate emissions would be minor from blasting and ore production operations if these operations were restricted in strong wind and water sprays were used to control dust in the pit staging areas. The floor of the pit would be relatively sheltered from wind most of the year.

Table V-4

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS), ESTIMATED PREVENTION OF SIGNIFICANT DETERIORATION INCREMENTS, AND WORST CASE PROJECTED CONCENTRATIONS

Pollutant and Averaging Time	NAAQS ($\mu g/m^3$)	PSD Increment ($\mu g/m^3$)[1]	Worst Case Projected Concentrations ($\mu g/m^3$)[1]
Sulfur Dioxide			
3-hr	1,300	512	80
24-hr	365	91	20
Annual	80	20	17
Nitrogen Dioxide			
Annual	100	NE[2]	74
Carbon Monoxide			
1 hr	40,000	NE	NE
8-hr	10,000	NE	NE
Particulate Matter[3]			
24-hr	150	37	13
Annual	60	19	13
Ozone			
1 hr	235	NE	NE
Lead			
Calendar Quarter	1.5	NE	1.2

---

[1] Source: Dames & Moore, 1983c.

[2] Has not been established.

[3] Fugitive particulate matter emissions were not included in calculations of concentrations.

Table V-5

EPA SIGNIFICANT EMISSION RATES

Pollutant	Significant Emission Rate Mg/yr	tons/yr
Sulfur Dioxide (SO_2)	36.3	40.0
Nitrogen Oxides (as NO_2)	36.3	40.0
Carbon Monoxide (CO)	90.7	100.0
Particulate Matter (PM)	22.7	25.0
Ozone (O_3)	36.3	40.0
Lead (Pb)	0.5	0.6

Dust controls would be most effective on the ore haul road and the waste rock storage piles. Adequate controls on the ore haul road could be water sprays (once or twice a day in dry weather), and an annual application of a suitable stabilizer. Dust generation would be a potential problem 30 to 60 days a year, primarily from June through August.

Control of dust from the waste rock storage pile would require aerodynamic shaping and orientation to the prevailing wind (north to south). Wind screen berms of rock and water sprays could be used to protect fine grained material. Revegetation would be attempted on those areas which had reached their final configuration.

Significant point sources of emissions at the mill site would include concentrate dryers, the crusher baghouse and the power plant (Table V-6). Minor and insignificant sources would be from utility and passenger vehicles, fuel storage and aircraft operations.

Based on the significant emission rates in Table V-5, the Red Dog project would be a significant pollutant source for SO_2, NO_x, PM, O_3 (calculated from volatile organic compound [VOC] emissions) and Pb, but not CO. Therefore, BACT would have to be demonstrated for all five pollutants.

The type of power plant engines proposed for this project would be capable of meeting BACT requirements. NO_x emissions would be within the proposed

Table V-6

ESTIMATED SOURCES AND AMOUNTS OF EMISSIONS FROM PROJECT COMPONENTS[1]

EMISSION SOURCES	SO_2		NO_x (as NO_2)		CO		PM		O_3 VOC (as hexane)[2]		Pb	
	Mg/yr	(tons/yr)	Mg/yr	(tons/yr)	Mg/yr	(tons/yr)	Mg/yr	(tons/yr)	Mg/yr	(tons/yr)	Mg/yr	(tons/yr)
Power Plant	5.2	5.7	318.0	350.5	9.3	10.3	0.2	0.2	77.6	85.6	0.0	0.0
Zinc Concentrate Dryer[3]	25.2	27.8	315.1	347.3	45.5	50.2	18.2	20.1	377.2	415.8	0.9	1.0
Lead Concentrate Dryer[3]	6.6	7.3	82.6	91.1	12.0	13.2	4.8	5.3	98.9	109.0	3.4	3.7
Barite Concentrate Dryer[3]	6.6	7.3	82.6	91.1	12.0	13.2	4.8	5.3	98.9	109.0	0.0	0.0
Crusher Baghouse	0.0	0.0	0.0	0.0	0.0	0.0	4.4	4.8	0.0	0.0	0.2	0.2
Drilling, Blasting	0.0	0.0	0.0	0.0	0.0	0.0	9.2	10.2	0.0	0.0	0.4	0.5
Ore Loading and Hauling	1.3	1.4	3.6	4.0	2.7	3.0	113.8	125.4	0.3	0.3	0.1	0.1
Crusher Feed	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.6	0.0	0.0	0.0	0.0
Waste Ore Stockpile	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.8	0.0	0.0	0.1	0.1
Fuel Storage	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.5	0.0	0.0
TOTAL	44.9	49.5	801.9	884.0	81.5	89.9	156.6	172.7	653.3	720.2	5.1	5.6

[1] Source: Dames & Moore, 1983c

[2] Ozone (O_3) levels may be calculated from volatile organic compound (VOC) emissions.

[3] SO_2, NO_x, CO and VOC emissions from the concentrate dryers would originate in the power plant internal combustion engines and would be ducted to the dryers with power plant exhaust gases.

standards without modifications. The recently set New Source Performance Standards (NSPS) for stationary internal combustion engines (larger than 560 in^3 per cylinder or 1,500 in^3 per rotor) require that NO_x emissions not exceed concentrations of 600 ppm. Satisfying the NSPS might also satisfy BACT requirements. Meeting SO_2 emission standards would require use of low-sulfur diesel fuel. VOC and CO could be controlled by proper maintenance procedures. PM emissions from the dryers would be controlled with a high-efficiency particulate collection system. Water sprays would be used to control dust on access and ore hauling roads. Dust from the crusher would be controlled by a baghouse. Lead would be controlled by the high-efficiency particulate collection system on the dryers. Details of emissions control systems would be provided through the PSD permitting process.

PSD increments are ambient pollutant concentration limits which legally define to what extent pollutant concentrations in an area are permitted to increase above a set baseline for all future time. The preliminary impact estimates for the Red Dog project might be less than the PSD increments.

Overall air quality impacts of the power plant emissions plume were estimated using the EPA Valley model. Assumptions made included a conservatively low plume height, worst case meteorological conditions, and peak rate 24-hour emission concentrations. Results of the model estimate indicated that the most likely power plant plume impact area would still be in compliance with the applicable NAAQS and PSD increments for all pollutants (Table V-4). Thus, while the project would exceed the EPA Significant Emission Rates and require BACT, impacts to the area would not be significant because the overall NAAQS would be met.

The worst case analysis discussed in the preceding paragraphs did not consider a rather infrequent condition important for protection of the health of workers. In extremely stable conditions when an inversion would be located immediately above the power plant emission plume, the plume could reach ground levels in the vicinity of the nearby worker housing complex. Because of this possibility, it would be important that the accommodation complex be located upwind from dominant wind directions from the power plant, or sufficiently upslope to be above a low lying inversion over the power plant. Monitoring alarms for carbon monoxide installed at the accommodation complex would alert workers in the event unusual atmospheric conditions caused the power plant emission plume to move in that direction.

Protection of air quality also would require proper operation of solid waste incinerators. No visible dark or black smoke would be permitted. Refuse which could not be burned with colorless or white smoke would be buried in the tailings pond.

Visual Resources

According to the Visual Resources Management (VRM) Program, Red Dog Valley was generally rated as having high visual quality with a variety class rating of common. However, the remoteness of the mine area limits the number and sensitivity of potential viewers. It should be kept in mind that all mine area facilities would be located on private land and the VRM Program as a management system is not applicable to private land. The discussion below, therefore, would be primarily of benefit to NANA as the landowner in its joint management of the project.

The mine site would be located within a partial retention Visual Quality Objective (VQO) zone. This designation normally permits management activities which would not dominate the existing landscape. Activities which would introduce different form, line, color or texture would be acceptable as long as they would remain secondary to the visual strength of the landscape. Activities which would repeat the form, line, color or texture of the landscape would be compatible with the partial retention objective.

The landscape character of the mine site area has a moderate ability to absorb visual changes. The visual changes which would be associated with the development include surface rock excavation and road construction between the mine and mill sites. The proposed changes would be viewed primarily by construction and mine related workers at or arriving at the site. Only a small proportion of these viewers would be expected to have a concern for scenic quality.

The mine site following surface mine excavation would appear as an oblong depression approximately 152 m (500 ft) deep, 305 m (1,000 ft) wide and 853 m (2,800 ft) long. Water and runoff would collect at the base of the depression.

The tailings pond would be located in an area characterized by gently sloping hills and valleys. Variety class at the pond site was rated as common due to the typical character of the area landscape. Few visitors other than mine related personnel would be expected to view the tailings pond. Due to this consideration and the likelihood that few of the viewers would have a specific concern for scenic qualities, the tailings pond site was rated as having a low sensitivity level.

The VRM system visual quality objective for the tailings pond site has been designated as partial retention. Again, to adhere to the visual objectives, proposed changes should not visually dominate the area landscape.

The visual absorption capability of the area is moderate owing to the gentle, consistent slopes surrounding the proposed tailings pond. During project operation, the tailings pond would be visible from aircraft flying directly overhead. Proposed pond reclamation activities would include regrading waste rock, capping the surface and revegetating the slope. The resulting color and textural changes would be secondary to the existing expansive landscape character. The approximately 46 m (150 ft) high dam and flat surface of the reclaimed pond would remain visible and create a contrast in line and form to the surrounding landscape. The level of contrast, however, would be consistent with the partial retention objective.

The mill site, worker housing site and airstrip would be located to the west, upslope from the tailings pond site. Visual variety was rated common for all three sites and a low sensitivity level designation would be appropriate.

The visual quality objective for the three sites would be partial retention. The facilities would be visible from aircraft and surrounding hilltops, however, they would be dwarfed by the expanse of the surrounding landscape. Visual changes would include the construction of several buildings, a narrow airstrip and connecting access roads. Again, few scenic viewers would likely see the sites since the facilities would be located in the far background.

The visual absorption capability of the sites is moderate due to the gentle slopes which characterize the area. Dark colored soils would blend with the background vegetation. Reclamation plans would include disassembling all structures to ground level. Access roads and the airstrip would be permitted to return to a natural vegetated condition. Evidence of the facilities eventually would not be visible.

The water supply reservoir on Bons Creek would be located on gentle slopes southwest of the proposed airstrip. The partial retention visual quality objective assigned to the area would be maintained and possibly enhanced by the reservoir that could add aesthetic variety to the landscape. The reservoir would not be removed at the end of the project unless desired by NANA or state agencies.

Sound

Noise impact analysis of the proposed project requires an inventory of noise sources and noise sensitive receptors. Noise sensitive receptors would be people or wildlife that could be adversely affected. Noise sensitive people would be basically restricted to visitors to Cape Krusenstern National Monument and, to a lesser extent, subsistence hunters who may feel that their traditional hunting grounds would be adversely affected by noise. Wildlife species most sensitive to noise would include caribou, bears, muskoxen and nesting raptors.

Noise emanating from the open pit would not propagate past surrounding slopes and ridgetops since sound normally travels in straight lines. Noise sources would include blasting, dozers, front-end loaders and ore hauling trucks.

Estimated sound pressure levels generated at mine area facilities are shown in Table V-7. Blasting sound pressure levels are normally thought of as relatively loud noises. However, blasting noise propagates in lower frequencies somewhat like a thunderclap. Low frequency sound of this type would usually be tolerable since it would normally occur at most only two or three times a day. The other mine site sound sources, assuming six or seven pieces of equipment would operate at any one time, would combine to a sound level of 100 dB(A) at 15 m (50 ft) and 65 to 75 dB(A) at the surrounding hilltops. There would normally be few sensitive receptors in the vicinity of the mine other than workers.

Major sound sources at the mill site, worker housing site, access roads, airstrip and water supply reservoir are estimated in Table V-7. Assuming a time of simultaneous activity, the combined sound pressure level would be 66

Table V-7

ESTIMATED SOUND LEVELS GENERATED BY MINE AREA EQUIPMENT AND FACILITIES

Sound Source	Sound Pressure Level[1] dB(A)
Blasting	170 @ 91 m (300 ft)
Bulldozers	87 @ 15 m (50 ft)
Front-End Loaders	90 @ 15 m (50 ft)
Ore Trucks	90 @ 15 m (50 ft)
Primary/Secondary Crushers/ Grinding Mill	95 @ 15 m (50 ft)
Diesel-Powered Generators	100 @ 15 m (50 ft)
Utility Vehicles	80 @ 15 m (50 ft)
Worker Accommodations	60 @ 15 m (50 ft)
Aircraft Operations	95 @ 15 m (50 ft)
For Comparison:	
OSHA Regulation (15 min exposure)	115 (max. allowable)
Discotheque	110 on dance floor
Jackhammer	95 @ 15 m (50 ft)
OSHA Regulation (8 hr exposure)	90 @ ear
Automobile (100 km/hr [62 mi/hr])	71 @ 15 m (50 ft)
Typical Outdoor Noise (wind, rain, birds)	40 @ 15 m (50 ft)
Soft Whisper	35 @ 2 m (6 ft)

---

[1] The sound pressure level in decibels (dB) corresponding to a sound pressure (P) is compared to a reference level of 20 micropascals. Sound pressures for various frequencies of noise are weighted by factors (A weights) which account for the response of the human ear. The sound pressure level in dB(A) = 20 Log_{10} (P/20).

dB(A) at a distance of 2.4 km (8,000 ft) on Volcano Mountain (Fig. II-1); a level above natural noise levels. Beyond the surrounding hills, sound generated by mine area facilities and equipment would not propagate at levels above those caused by wind and rain.

Cultural Resources

Four archeological sites are located in the immediate area of the mine site. Two of these could not be avoided during ore removal, and therefore they would be evaluated for eligibility to the National Register of Historic Places. If eligible, mitigation actions would be included in the Advisory Council on Historic Preservation (ACHP) commenting procedures covered by a Memorandum of Agreement concluded among the State Historic Preservation Officer (SHPO), the ACHP and the federal agencies permitting the project.

Wherever feasible, road alignments and other facilities would be designed to avoid direct impact on known archeological sites determined eligible for the National Register. If such sites could not be reasonably avoided, or otherwise protected, recovery of data would be accomplished in accordance with the stipulation of an ACHP Memorandum of Agreement. Similarly, sites in borrow pit areas would be avoided if possible; if not possible, recovery operations would be accomplished pursuant to an approved research design. Provisions would be made in the Memorandum of Agreement for emergency recovery operations at sites discovered during construction.

Subsistence

Four impacts on subsistence resources and harvest activities are considered below: habitat degradation; interference with fish and wildlife life cycles or migration patterns; increased harvest pressures; and incompatible work arrangements.

Kivalina and Noatak are the settlements nearest the project area. Since Kivalina residents rely more heavily on a wider variety of subsistence resources (e.g., caribou, Arctic char, marine mammals) present in the project area, that community would be more likely to experience any adverse impacts on the subsistence resource base. However, Noatak residents also rely for an important part of their subsistence on the fish and wildlife resources of the area.

The mine site vicinity possesses little value for subsistence or recreational fishing and hunting. There are no resident fish or wildlife resources of any importance, and this area is at the margin of use areas for Noatak and Kivalina residents. Based on the assessment of environmental effects of mine site operations on surface lands and water quality, the mine would not cause any material loss of habitat.

The valley of the South Fork of Red Dog Creek is outside the prime wintering grounds for caribou, but may support occasional winter grazing. Subsistence would be adversely affected if mine construction and operation disturbed established winter grazing in a way that reduced the caribou resources usually available for harvest by Kivalina and Noatak residents.

Caribou might also become subject to increased local hunting pressure from employees based at the mine, though hunting, fishing and trapping would be restricted while workers were at the site. Presumably, resident employees would be more inclined to hunt during off-duty hours than out-of-region workers. Since most of the resident workers would come from villages that do not usually hunt in the Red Dog area, any hunting by them could increase subsistence harvest pressure above present levels. The dynamic equilibrium between caribou habitat and migration patterns, and herd population and harvest pressure, is complex. The net subsistence outcome from geographical shifts in caribou movements or from increased hunting activity would not be simple to predict.

There would be potential that employment at the mine would have adverse effects on the persistence of traditional subsistence patterns. Whether these effects materialized would depend in part on how well work schedules and commuting patterns could be adapted to minimize conflicts with subsistence requirements.

First, there would be some cause for concern that closer involvement in wage employment and the cash economy might gradually erode interest in subsistence or lessen subsistence success. There is some suggestive evidence to the contrary in some recent sociocultural studies (John Muir Institute, 1983) which conclude that regular but flexible employment can be compatible with continued subsistence participation and superior subsistence success. The John Muir Institute study found a strong positive correlation between high cash income and subsistence success, perhaps because cash income enables subsisters to acquire better equipment for their task.

Second, safe, efficient operation of the mine would require a stable, year-round work force. Consequently, a high level of resident employment would hold some potential to disrupt either traditional subsistence patterns or mine operations, especially during the prime periods in the annual subsistence cycle. Many of the subsistence resources that are most important to residents of the region are highly seasonal in availability. For example, the prime periods to harvest salmon, Arctic char and marine mammals are very brief, a few weeks or less each year. If the work rotation preempts these opportunities, there would be some loss of subsistence income.

The mining plan tentatively calls for a two-week rotation schedule for the on-site workforce, including employees who reside in the region. This would allow for subsistence harvest participation during time off. Also, it should be noted that the availability of subsistence resources and the seasonal subsistence harvest cycle is not uniform throughout the region's communities. This, too, might allow some leeway for adjusting work rotations to minimize conflicts with subsistence. For the long run, the coexistence of traditional subsistence activities and employment at the mine would depend on the flexibility of work arrangements and the ability of individual mine workers to retain and pass on their subsistence skills. This is an important project objective for NANA.

Socioeconomics

The proposed project's socioeconomic consequences would be largely determined by certain fixed features of the project, e.g., the isolation of the mine, port site and transportation corridor from existing settlements, and the choice of a transient campsite for workforce support rather than a permanent townsite. Socioeconomic impacts would also be sensitive to certain entrepreneurial and managerial decisions. Under terms of the NANA/Cominco agreement, NANA participates in decisions and policies about design and operation of the mine that may affect local interests. NANA's official posture strongly reflects its perception of the development concerns and preferences of the region's residents. The NANA/Cominco agreement binds Cominco to managerial and labor policies designed to magnify positive socioeconomic impacts and mitigate adverse social impacts. For this environmental consequences assessment, it was assumed that the terms of this contractual agreement would govern the project. Where the agreement aims at, but cannot guarantee, such goals as a high level of resident hire, the analysis relies on our most realistic estimate of project impacts.

Four potential socioeconomic impacts are considered below: regional employment and income; population growth and migration; demand for community infrastructure; and social, political and cultural stability and autonomy.

Project alternatives mainly involve variations in the overland transportation corridor, port site and type of transfer facility. However, the project factors that critically affect socioeconomic impacts would be constant for all options. In terms of the most important socioeconomic impacts, there would be no material difference among the project alternatives.

Regional Employment and Income

The economic impact of the Red Dog project on the region would stem partly from the new basic jobs and earnings the project would provide residents, and partly from the stimulus that this basic economic growth would contribute to the secondary economy.

For purposes of regional economic impact analysis, the Red Dog project can be usefully divided into a construction phase and a production phase. The construction phase would cover the 30-month period during which the mine project site and transportation system would be developed. As now planned, construction would begin during the winter of 1985-86 and be completed by the end of 1987 (Fig. I-2). The mine would begin production by early 1988 and reach full production by about 1994. This assessment assumes that the project would proceed on schedule. A few years' delay in the start of the project would postpone but not materially change the socioeconomic impacts. Cominco's present mining plan aims at a total annual shipment of 434,450 Mg (479,000 tons) of combined ore concentrates during the initial phase of production. Changed market conditions or other factors could raise or lower that production goal. However, the mining and milling operation could support higher output with only marginal added labor.

Cominco estimates that direct project employment would be 372 jobs for construction and 424 jobs for production. Table V-8 shows the employment breakdown by occupational group. There would be some overlap in the occupational skills required for each phase, especially among equipment operators and skilled trades.

Table V-8

AVERAGE ANNUAL EMPLOYMENT BY OCCUPATIONAL GROUP

CONSTRUCTION PHASE		PRODUCTION PHASE		
Craft	Number	Craft	Initial	Final
Carpenters	29	Management	7	7
Boilermakers	10	Supervisors	30	30
Electricians	21	Professionals	9	11
Instrumentation	4	Technical/Clerical	51	53
Insulators	3	Equipment Operators	64	72
Ironworkers	31	Mill Operators	22	28
Laborers	57	Tradesmen	69	93
Linemen	6	Trainees	84	68
Millwrights	11	Laborers	16	22
Painters	4	Catering	40	40
Pipefitters	21	Total	392	424
Equipment Operators	78			
Sheet Metal	4			
Truck Drivers	54			
Pile Drivers	14			
Management & Clerical	25			
Total	372			

Source: Cominco Alaska, Inc.

Cominco projects an annual gross payroll (1983 dollars) of $23.1 million for the construction phase and $13.4 million for the final production phase. Average annual earnings per job amount to about $62,000 during construction and about $31,700 during production. This earnings differential would be due to such factors as different work schedules and occupational mixes for the two phases.

In order to assess the economic impact of project payrolls on the NANA region, it was necessary to estimate how many of these direct jobs would be filled by residents, how many non-resident employees might eventually take up residence in the region, and how much secondary employment might be generated by basic employment in the mining project.

The management agreement between Cominco and NANA set a goal of maximum resident hire, entitled NANA to nominate the project personnel officer, and established a joint committee to prepare a manpower inventory and identify manpower training needs. The success of the employment goal would depend on a number of factors such as the number of qualified residents seeking work at the mine, the effectiveness of resident training programs, and the compatibility of work and rotation schedules with other important interests of potential employees, particularly subsistence pursuits.

Because of the unprecedented nature of this project for the region, projections of the level of resident hire are necessarily speculative (Table V-9). Based on a review of the construction workforce composition compared to the size and occupational skills of the resident labor pool and current unemployment and workforce participation rates, it was estimated that about one-third (124) of the construction jobs would be filled by present NANA region residents.

During the production phase, all on-site positions would be filled on a rotation basis by workers billeted in camp quarters. Cominco's preliminary operating plan foresees a two-week on/two-week off rotation for all on-site employees, with 12-hour work days for operating crews and 10 to 11-hour days for support crews.

For the production phase, Cominco estimates that regional residents would fill about 168 jobs at production start-up, climbing to about 267 jobs by the final production stage. This is a relatively high level of resident employment for a large remote project in rural Alaska. However, these estimates appear feasible in view of the skills employed by the project and available in the region's workforce, and in view of the joint commitment of NANA and Cominco to recruit, train and employ local residents.

The non-resident jobs would be filled by transient workers who would commute between the jobsite and permanent residences outside the region. Cominco would pay round-trip air transportation costs for all on-site employees. This transportation agreement would also make it easy for non-local workers on the project to retain their prior residences and discourage them from resettling into the region. For purposes of estimating economic and population impacts, it was assumed that only five percent of the non-local production workforce would take up permanent residency within the region. This group would include former residents returning to the region as well as newcomers.

Table V-9

ESTIMATED TOTAL RESIDENT EMPLOYMENT IMPACTS[1]
NANA REGION

	Direct[2] Resident Employment	Secondary[3] Resident Employment	New[3] Resident Employees	Total[3] Resident Employment
Construction	124	100	75	299
Pre-production	168	86	96	350
Final Production	267	162	118	547

[1] For purposes of meaningful regional analysis, project employment is assigned by residence of the worker rather than by the jobsite. By Alaska Department of Labor and U.S. Census economic and demographic statistical reporting units, the minesite is situated in the North Slope Borough.

Source:

[2] Cominco Alaska, Inc.
[3] Kevin Waring Associates, 1983

Based on these assumptions, the prorated share of direct income to region residents would be about $6.9 million during the construction peak and rises to about $8.4 million by the time the mine reaches full production (Table V-10).

In addition to direct employment of residents, the mine project would trigger other changes in the region's employment and economic structure, especially at Kotzebue. First, the added purchasing power injected by mine payrolls would pump up local purchases of goods and services. This would stimulate secondary economic growth, broadening the range of locally available goods and services for everyone and creating new jobs in the support sector. In order to calculate the effects of the mine payroll, a basic to nonbasic employment ratio of 1.0 to 0.3 was used for the construction phase, rising to 1.0 to 0.4 for the production phase. This employment multiplier, though low

Table V-10

PROJECTED ANNUAL PERSONAL INCOME
($ million)

	DIRECT INCOME			INDIRECT INCOME
	Resident[1]	Non-resident[1]	Total[2]	Resident Only[1]
Construction	6.9	16.2	23.1	2.1
Initial Production	5.2	7.0	12.2	1.8
Final Production	8.4	5.0	13.4	3.4

Source:

[1] Kevin Waring Associates, 1983

[2] Cominco Alaska, Inc.

by national standards, is typical of Alaska's remote regional centers and allows for some expansion in the region's secondary economy.

Second, it is plausible that many, perhaps most, of the residents hired for the mine would be recruited from other jobs in the region, leading to a period of job shuffling. These vacated positions would become available for other underemployed and unemployed resident workers. If the vacated posts were not readily filled from the resident labor pool, some of the jobs might draw newcomers to the region to replace mine hirees. In this way, resident hire on the mining project would trigger upward job mobility throughout the region's labor pool and might also attract some new residents to the region. In all, it was estimated that about two-thirds of the combined vacated or new secondary posts would be filled by residents, with the rest filled by newcomers or former residents. On this assumption, there would be about 118 new workers moving into the region to take up jobs created by the mine project.

The proposed project would provide permanent, year-round employment in a developing region with substantial unemployment and underemployment. The project management, as expressed by the NANA/Cominco agreement, places high priority on policies and practical steps designed to make feasible a high rate of resident hire. Apart from the mine, there are no projects in the region that seem likely to improve economic or job conditions to a significant extent. At final production, the project would contribute about 547 jobs and an annual payroll of $11.8 million to NANA region residents. For comparison, the Alaska Department of Labor reports that in 1982, the average annual employment for the Kobuk census division was 1,863 employees, with a total annual payroll of $39.0 million. Thus, compared to 1982 levels, the mine project at final production would increase resident employment by about 29 percent and resident earnings by about 30 percent. The project would also create about 248 construction jobs and about 157 permanent production jobs for workers commuting from other areas of the state, plus an undetermined number of secondary jobs.

The economic impact of the project would accelerate during construction and then level off as production began. Sudden prosperity might cause some transitional problems (e.g., price and labor inflation) in the local economy until the local supplies of goods and services and labor adjusted to meet new consumer demand. For the long run, however, it seems probable that economic growth would promote local diversification and economies of scale to offset short-term inflation.

Development of a deep-draft port facility for shipment of ore concentrates could lower shipping costs for fuel and other cargo delivered to the region. A fuels and general cargo depot, from which in-bound goods could be redistributed to villages, would avoid the lightering costs for shipment through the port of Kotzebue.

Population Growth and Migration

It was estimated that the mining project would eventually add about 354 persons to the total population of the region above the baseline forecast without the mine (Table V-11). Much of this growth would occur at the early stages

Table V-11

PROJECTED POPULATION IMPACT
NANA REGION

	Newly Resident Employees	Cumulative Growth Impact
Construction	75	225
Initial Production	96	288
Final Production	118	354

Source: Kevin Waring Associates, 1983

of the project. This would include an estimated 118 new resident workers, plus their households. It was assumed that Kotzebue's more developed commerce, transportation and community facilities and services would make it more appealing to newcomers than the smaller remote communities. Therefore, nearly all (about 90 percent) of these new residents would probably reside in Kotzebue, with the rest dispersed among the other rural villages (Table V-12).

Table V-12

ESTIMATED POPULATION - BASE CASE AND IMPACT CASE
NANA REGION

	NANA Region		Kotzebue		Villages	
Year	Base Case	Mine Case	Base Case	Mine Case	Base Case	Mine Case
1982	5,343	5,343	2,470	2,470	2,873	2,873
1986	5,671	5,896	2,622	2,824	3,049	3,072
1990	6,019	6,307	2,782	3,041	3,237	3,266
2000	6,985	7,339	3,229	3,548	3,756	3,791

Source: Kevin Waring Associates, 1983

Recent decades show a pattern of intraregional migration to Kotzebue from its hinterland villages, but this trend appears to be leveling off. The effects of the mine project on population movements within the region are, at best, speculative. On the one hand, Kotzebue's more developed cash economy and community services may prompt some migration there of village residents working at the mine. However, provision for direct commuting rather than via Kotzebue, plus a preference of village residents to use new income to make their families better off in their home communities might neutralize this tendency. A best guess was that the project would not have much net effect on intraregional population movement.

Demand for Community Infrastructure

All elements of the proposed project (mine area facilities, overland transportation corridor and port facilities) would be remote from existing communities. Cominco would provide at the mine site all support infrastructure for its employees, including camp quarters, recreational facilities and emergency medical services. Worker housing would also be provided at the port for emergency use, and for temporary use by ship loading and road maintenance crews. Cominco would provide charter flight pick-up and return to the home village of resident employees, and via Kotzebue or Point Hope to Anchorage for non-resident workers. Thus, the mining project would not compete with existing communities for state or federal community development programs.

However, former residents and newcomers drawn to the region to work on the project or to take advantage of other work opportunities opened up by the project would generate some demand for new community facilities and services. As the region's transportation and commercial center, Kotzebue would feel the brunt of this growth. It is estimated that Kotzebue's population would grow by about 200 persons during construction and by another 100 persons during production, for a net growth of about 300 persons or 10 percent due to the project (Table V-12).

The bulk of this population growth would derive from secondary economic growth at Kotzebue rather than from the mine itself. Since this growth would be concentrated during the construction and early production phases, it would likely impose some short-term strains on the capacity of the community to meet the housing needs and other community facility and service needs of new residents. It is also plausible that the incidence of social problems might rise while resident workers and their families adjust to new working and living arrangements and to improved economic circumstances. Coordinated advance planning by the City of Kotzebue and other responsible public agencies, with programs linked to progress in the mine development schedule, would help mitigate these stresses of rapid community growth.

Few new residents would be expected to settle in the rural communities, so minimal impact on their community facilities and services would ensue from the mining project.

Social, Political and Cultural Stability and Autonomy

The isolated, self-enclosed mine camp facilities would tend to buffer the existing communities from the most disruptive social impacts often associated with large resource development projects in undeveloped rural regions. Cominco would not establish a permanent townsite that might eventually incorporate as a local government. Ultimately, more than half of the permanent workforce would be drawn from the resident labor pool. An estimated 354 new residents or about a 5 percent increment to the base case regional forecast would accrue from the project over a period when the region would not be otherwise projected to undergo much economic or population growth. All these circumstances would tend to moderate any potential disruptions of the prevalent political, social and cultural equilibrium, except at Kotzebue which would receive the brunt of growth impacts.

The collaborative role of NANA Regional Corporation, to which most residents belong, in the development and management of the proposed project would also serve to avoid or moderate adverse impacts. The management agreement between NANA and Cominco contains many features designed to eliminate or blunt aspects of the project that might clash with traditional lifestyles and cultural values. Undeniably, the project presents new choices to residents about how to make their livelihoods. However, these choices would not be imposed by forces wholly outside local control, but would arise from a purposeful, calculated development policy by the regional corporation. Furthermore, the management agreement between NANA and Cominco provides a flexible, ongoing framework for resident involvement in project decisions to adjust for unexpected problems or changing conditions.

Because there would be no permanent incorporated settlement at the mine site requiring public services, the mine facilities would not alter the governmental status quo or impose any burdens on local governments.

Outside the incorporated cities, the NANA region is part of the unincorporated borough. There are no plans to alter that status. The mine and most of the related facilities would be in the North Slope Borough. Thus, the project would offer limited revenue potential for a borough that might be incorporated in the NANA region, unless the Borough's boundaries were adjusted to match Native regional corporation boundaries.

However, as noted earlier, Kotzebue would be subject to an influx of new residents. This might dilute the cultural and social status of established residents and perhaps upset the local political equilibrium. Apart from sales taxes, population growth would not generate much additional local governmental revenue since the City of Kotzebue does not levy a real property tax. If rapid growth overtaxes the community's fiscal resources to maintain services for both existing residents and newcomers, it might be a source of community conflict.

It appears that the potential for any severe adverse or disruptive socioeconomic impacts on the region would be well contained by the isolation of the project from existing communities and by the mediating role of the NANA Regional Corporation in the development and ongoing management of the project. The relatively low level of adverse socioeconomic impacts would be partly attributable to conscious policies and decisions jointly made by NANA and Cominco about the development scheme and mode of operations for the mine. In particular, the choice of workcamp quarters, rather than a full-fledged permanent townsite, to support a transient workforce composed mostly of local residents on a rotation schedule avoids many of the adverse and potentially disruptive impacts that a major remote resource development project might have on a remote, lightly populated and undeveloped region.

On the other hand, the project has substantial potential for positive long-term impacts on employment and income opportunities for the region's residents. However, capture of these positive impacts would depend on the success of programs to recruit and train workers from the resident labor pool. If the effort to achieve a substantial degree of resident hire falls short, then it would be necessary to import more non-local workers. In that case, the income benefits to residents of the region would diminish.

A high rate of resident hire would be triply beneficial in terms of socioeconomic impacts. First, it would permanently boost resident income and employment. Second, it would limit the scope of new demands on existing infrastructure by reducing the number of non-local mine employees who might opt to take up local residence. Third, by reducing the potential for new settlement in the region, it would allow for economic development while still conserving resident control over the region's political, social and cultural institutions and resources.

Most of the growth impact anticipated from the project would be concentrated on Kotzebue. This would impose some growth management problems on a community whose fiscal and physical resources to accommodate much new growth are already limited.

Recreation

As areas accessible to state population centers become more used, those seeking fairly primitive recreational opportunities might be drawn to the Red Dog project area. Recreational use of the project area currently represents only a very small percentage of the total statewide recreation. However, as more information about the area is made available to the public, local recreational use might change. The proposed project might affect the amount and direction of such recreational use change.

When not engaged in work related activities, Cominco employees would be free to recreate, thus potentially increasing competition for local resources. To minimize these impacts, Cominco would prohibit employees from hunting, trapping or fishing during their active phase of work and residence at project locations, or while moving to or from their homes and work sites on Cominco transportation. Construction activities and mine operations could affect wildlife species sensitive to development and human intrusion. There could be temporary impacts and chronic local impacts, but no major impacts to recreational hunting and fishing on an areawide basis would be anticipated just from development of the Red Dog project.

COMPONENTS SPECIFIC TO SOME ALTERNATIVES

This section discusses the impacts of each project alternative on a discipline by discipline basis where certain components differ for each alternative. Components specific to Alternative 1 include a southern corridor to a port site at VABM 28, with a short causeway/offshore island transfer facility (Fig. III-3). Alternative 2 consists of a northern corridor to a port site at Tugak Lagoon, also with a short causeway/offshore island transfer facility. Alternative 3 consists of the southern corridor to VABM 28, with a short causeway/lightering transfer facility.

Vegetation and Wetlands

Alternative 1

Construction of an 89.9 km (56.2 mi) road in the southern transportation corridor from the mine area through Cape Krusenstern National Monument to the coast at VABM 28 would directly disturb a total of approximately 197 ha (487 ac) of vegetation. Approximately 55 percent of the corridor would be in the Wulik River watershed, approximately 35 percent would be in the Omikviorok River drainage, and approximately 10 percent would cross the upper reaches of the Noatak River watershed. Approximate road surface area intersection of vegetation types is shown in Table V-13. An estimated additional 84.4 ha (208.5 ac) of ground cover would be directly disturbed by development of borrow sites along the entire corridor (Table II-3; Fig. II-8).

Table V-13

APPROXIMATE AREA OF VEGETATION TYPES INTERSECTED BY ROADS IN THE TRANSPORTATION CORRIDORS

	Transportation Corridor	
	Southern	Northern
Total Length of Corridor	89.9 km (56.2 mi)	117.0 km (73.1 mi)
Total Area Intersected	197 ha (487 ac)	257 ha (634 ac)
Vegetation Type		
Tall shrub & complexes	2 ha (5 ac)	15 ha (38 ac)
Low shrub tundra & complexes	25 ha (63 ac)	10 ha (25 ac)
Closed low shrub & complexes	10 ha (24 ac)	64 ha (159 ac)
Open low shrub & complexes	20 ha (49 ac)	8 ha (19 ac)
Mat & cushion tundra	10 ha (24 ac)	15 ha (38 ac)
Elymus tall grass	<2 ha (<5 ac)	<2 ha (<6 ac)
Sedge-grass tundra	<2 ha (<5 ac)	18 ha (44 ac)
Tussock tundra	110 ha (273 ac)	110 ha (273 ac)
Tussock tundra-low shrub complexes	12 ha (29 ac)	2 ha (6 ac)
Sedge-grass marsh	2 ha (5 ac)	<2 ha (<6 ac)
Sedge-grass wet weadow	2 ha (5 ac)	10 ha (25 ac)
Sedge-grass bog meadow	2 ha (5 ac)	2 ha (6 ac)
Wetland herbaceous	<2 ha (<5 ac)	<2 ha (<6 ac)

Source: Dames & Moore, 1982a

If borrow material was taken only from sites outside Cape Krusenstern National Monument, approximately 49.1 ha (121.3 ac) of ground cover would be directly disturbed by borrow site development (Table II-4). Locations of potential sites are shown on Figures II-8 through II-13. It is anticipated that vegetation type disturbance would occur with a frequency and distribution similar to that for the main road.

Indirect effects associated with occasional foot traffic, off-road vehicle use, and dust would impact additional acreage. Snow covered ground inundated with off-road travel might be compacted, melt comparatively late, or show impeded drainage and increased erosion. Direct damage to uncovered vegetation might include breakage of plant parts, depression of the ground surface, ponding and increased erosion. In most cases the degree of impact would be unpredictable and would depend on the nature of the disturbance and the nature of the disturbed community (Brown and Berg, 1980).

Studies following three years of operation of the North Slope Haul Road from Atigun Pass to Prudhoe Bay indicate that road dust impacts could be substantial. Maximum dust fall might occur up to a distance of 300 m (984 ft) from the road, and early melt of dust covered snow might extend from 30 to 100 m (100 to 328 ft) on either side of the road. If borrow material was extracted only from sites outside the Monument, road dust impacts during road construction would be greater than if borrow sites were spaced along the entire corridor. This would be due to borrow being hauled further. Mosses and lichens would be most susceptible and might, with other heath and herbaceous plants, die or experience a loss of vitality along the road. Some taxa, for example cottongrasses, might increase in relative abundance in the roadside environment (Brown and Berg, 1980). Communities adjacent to the road would be contaminated by any fuel, chemical, or concentrate spill. The degree of impact would depend on the nature of the site and spill, time of year and cleanup procedures.

The road would compact the ground and might impede local drainage. In general this impact could be minimized by proper bridge and culvert construction, but might occur where drainage patterns were more diffuse. Some impounding of water might occur on the upslope side of the road and some draining or drying might occur on the downslope side of the road. Change, more than loss, of vegetation would be expected in response to changes in soil type, moisture regime and topographic setting caused by the road.

A large proportion of the road would pass through areas technically classified as wetlands, and wetland impacts would involve a number of vegetation types occupying a range of sites that may differ in soil type and moisture regime. Therefore, associated wetland values might also differ. Wetland values are determined by the degree to which wetlands perform various ecological functions. Such wetland functions include: providing productive habitat; cycling nutrients and energy; maintaining water quality; moderating erosion and flooding, and regulating surface water flow. As habitat values cannot always be described by the vegetation classification system used here, potential impacts on habitat are addressed in the Terrestrial Wildlife and Biology sections of this chapter. Some interactions with and potential impacts to the watersheds of the region are addressed in the Hydrology and Water Quality Section.

Loss of sedge-grass tundra wetlands would be small. Loss of tussock tundra, tussock tundra-low shrub complex and open low shrub and complex wetland communities would be much larger. However, these impacts would not be considered regionally significant, as the loss of these vegetation types would be small relative to overall occurrence in the project area. Wetland values associated with these vegetation types probably would be low to moderate along the corridor, but might be somewhat greater for communities occurring in lowland basins or areas of diffuse drainage. Open low shrub and complex communities occurring in riparian zones might also have greater wetland value. In addition to open low wetlands, other tall and low shrub riparian wetlands would be impacted by the 187 stream crossings required for development of the southern corridor. The loss, however, would be small compared to overall occurrence and would not be considered regionally significant.

Vegetation types of generally moderate to high wetland value are the sedge-grass marsh, wet meadow, and bog meadow communities. It is estimated that 6 ha (15 ac) of such vegetation would be directly lost. This would represent approximately 0.4 percent of such wetlands within a 0.8 km (0.5 mi) wide corridor from the ore body to the port site. A regionally insignificant loss of wetland herbaceous community might also occur.

Development of the port site at VABM 28 would directly disturb about 20 ha (50 ac) of sedge-grass marshland, Elymus tall grass and tussock tundra vegetation. In addition to storage and power generation facilities located on the coast, a concentrate storage building would be located about 4.0 km (2.5 mi) inland in an area scheduled to be disturbed by the removal of gravel. Elymus tall grass vegetation is not widespread and the loss would represent greater relative impact than for more common vegetation types. Value of the sedge-grass marsh wetlands would also be lost. However, these losses would not be significant on more than a local basis. Port site development might also cause erosion or aggradation of shoreline acreage with a resulting change in nearby coastal community types. Breaching Port Lagoon would cause salinity to increase in the lagoon waters. This would probably cause the lagoon shoreline vegetation to shift from freshwater to halophytic community types. In addition, fuel, chemical or concentrate spills might impact vegetation. The specific degree of change or loss would be unpredictable.

Alternative 2

Construction of a 117.0 km (73.1 mi) road in the northern transportation corridor from the mine area to the coast at Tugak Lagoon would directly disturb a total of approximately 257 ha (634 ac) of vegetation. Approximately 40 percent of the corridor would be in the Wulik River watershed, 40 percent in the Kivalina River watershed, and 20 percent in the Asikpak River watershed. Approximate road surface area intersection of vegetation types is shown in Table V-13.

An estimated additional 105 ha (260 ac) of ground cover would be disturbed in the development of borrow sites. These sites have not been specifically determined, but it was estimated that vegetation type disturbance would occur with a frequency and distribution similar to that for the main road.

Other impacts associated with road development would be similar to those for Alternative 1, although as the northern road would be slightly longer, overall impacts would be slightly greater.

With respect to wetlands, collective impacts to sedge-grass tundra, tussock tundra, tussock tundra-low shrub complex and open low shrub and complex would be less than that for Alternative 1. The northern corridor would cross three major river systems and numerous smaller streams for a total of 312 crossings, and would impact more associated tall and low shrub riparian wetlands than Alternative 1. Of particular importance would be impacts to the Wulik and Kivalina floodplain communities that offer some flood protection and provide valuable wildlife habitat. Impacts, however, are small compared to overall occurrence of these vegetation types and would not be considered regionally significant. Impacts to the sedge-grass marsh, wet meadow and bog meadow communities would also be slightly greater than those for Alternative 1. It is estimated that up to 14 ha (37 ac) of these community types would be lost. However, as in Alternative 1, the impact would be small compared to the total of similar wetland resources in the area and would not be considered regionally significant. A regionally insignificant loss of wetland herbaceous community might also occur.

Development of a port site at Tugak Lagoon would directly disturb about 20 ha (50 ac) of sedge-grass marsh wetland and complexes of Elymus tall grass and wetland herbaceous communities. As in Alternative 1, distribution of shoreline vegetation is more restricted on a regional basis and, therefore, its loss would represent a greater relative impact than more common vegetation types. However, the total vegetation and wetland loss at Tugak Lagoon would not be significant on more than a local basis. As for Alternative 1, lagoon breaching, change in nearby shoreline characteristics or potential spills might cause other changes in coastal vegetation types, but the specific degree of change or loss would be unpredictable.

Alternative 3

Vegetation and wetlands impacts would be similar to those for Alternative 1.

Terrestrial Wildlife

Alternative 1

Construction of the southern corridor road would cause a direct habitat loss of approximately 197 ha (487 ac). On a local basis this loss could be significant for song bird and small mammal species, but it would not be significant on a greater than local basis. For birds of prey and larger mammal species, direct habitat loss would not be significant even on a local basis.

Indirect habitat loss, however, would be of significance on a greater than local basis. While local song bird and small mammal populations would likely accommodate to the presence of the road and associated activities, birds of prey and larger mammals would generally be affected to differing degrees by avoiding the area. The degree of avoidance cannot be accurately predicted.

Several nest sites of birds of prey, including three of the endangered peregrine falcon, have been reported along the southern corridor. While the road alignment has been altered to provide a buffer of at least 3.2 km (2 mi) around the peregrine nests, in at least one case that has caused the road to more closely approach other species' nests (e.g., at Tutak Creek). Aside from road construction disturbance that might cause nest abandonment during the first two years of project development, long-term raptor breeding would likely not be seriously affected by road activity because of the distances from the nests. Secondary road effects, e.g., increased use by bird watchers, photographers, falconers and other visitors, if the road was eventually opened for general public use, would likely cause greater long-term impacts. Just the presence of the road, however, would probably modify feeding behavior and cause some avoidance of the road corridor.

Indirect habitat loss would likely be significant for caribou on a local basis, and could even be of greater than local significance. The southern corridor passes between current primary caribou low tussock tundra winter range in the Wulik and Kivalina lowlands, and secondary winter range on the more wind-swept slopes of the Mulgrave Hills to the southeast (Fig. IV-5). Road activity would cause avoidance of the corridor, and hence displacement, thereby limiting to some extent the use of otherwise available winter habitat. There would also likely be some mortality due to vehicle collisions or added stress from winter traffic.

Interruption of major movements would have the greatest potential impact upon caribou. In addition to affecting local movements, primarily during the winter, construction and operation of a road could cause major alterations in the historic movement patterns of the western Arctic caribou herd. From experience with other roads in Alaska, the approximately 20 to 25 vehicle round trips per day (excluding maintenance) associated just with the Red Dog project would be unlikely to cause such a major shift in movement patterns.

A high volume of traffic generated by additional users in the future, however, could have a significant impact. During the spring migration north to the calving grounds, the early summer post-calving concentration movements, and again during the autumn when large numbers of caribou move southeastward through the De Long Mountains and the project area, the presence of a very active transportation corridor might cause a significant change in migration patterns. Because of their dependence on often widely spaced calving, concentration and wintering areas, such interruptions could have a significant impact upon a large segment of the western Arctic herd, especially if they occurred with any frequency. In addition, many residents of the region living southeast of the project area depend upon caribou as a major staple of their subsistence diets and would be affected by any such change in movements. Thus, although construction and operation of a road for the Red Dog Project would not in itself likely cause major interruptions to caribou movements, it would open a road to increased future traffic that might cumulatively cause such interruptions.

The NANA/Cominco agreement specifically recognizes the possibility of major caribou migration interruptions. NANA has retained the authority to suspend operation of the project during periods when caribou movements are imminent to minimize the possibility of such interruptions. Still, the capricious nature of caribou may cause changes in movement patterns nonetheless. To maximize the probability that such good intentions would work, a specific monitoring plan should be developed in consultation with ADF&G to track major movements and make suspension decisions. This plan should be established before actual construction begins so adequate baseline data would be available.

Bears would be displaced from the area of the road corridor, and their movements between the lowlands of the Wulik and Kivalina Rivers and the Mulgrave Hills would probably be altered to some extent. No known areas of specific importance for denning or salmon feeding would be affected. The major impact to bears would likely be from long-term increased human access to the project area as discussed later.

Moose would not likely be significantly impacted by indirect habitat loss. The most important moose habitat is the riparian willow along Ikalukrok Creek and the Wulik and Kivalina Rivers. The southern corridor would be several miles to the east near the headwaters of the tributaries to the Wulik River. The road would pose no physical barrier to movements, and moose normally accommodate to vehicular traffic. There would be some mortality due to vehicle collisions or added stress from winter traffic. The major impact to moose would likely be from long-term increased human access to the project area, particularly by hunters.

The southern corridor traverses the home range of the small herd of muskoxen that appears to winter in the Rabbit Creek drainage southeast of the Mulgrave Hills. The potential impact on these animals from habitat loss due to road construction and operation would be unknown. As with bear and moose, the major impact upon muskoxen would likely be from long-term increased public access to the project area.

Limited waterfowl habitat exists along the southern corridor, the best being confined to small lakes, ponds and sedge-grass marshes. The road would cause no significant direct habitat loss, and relatively little indirect habitat loss. The major impact would be from long-term increased human access to the project area, particularly by hunters, or other visitors who might disturb molting or staging Canada geese.

Construction activities along the corridor, aside from direct habitat loss, would have relatively little impact upon song bird, waterfowl or small mammal species. Raptor nests near the road alignment, however, might be abandoned if construction activities occurred nearby during the critical period from the latter part of incubation through the first few weeks after hatching.

Construction activities would displace larger mammals to a greater degree than during operation of the road. This would probably not be of greater than local significance to bear, moose, sheep or muskoxen. Caribou, however, could be significantly impacted. With road construction scheduled to commence in February 1986, some caribou wintering in the Wulik and Kivalina

River lowlands would likely be displaced. Local movements between that area and current secondary winter habitat in the Mulgrave Hills would also likely be affected. Impacts upon caribou would be lessened if schedules were established which limited construction activities to the port site, South Fork Valley, and the coastal end of the road corridor until the northward spring migration had been completed (normally by early May).

Caribou early summer post-calving and autumn migrations might also be affected by road construction activities. The autumn 1986 southeastward migration in particular would be encountering the road corridor for the first time. Its physical presence alone might have an impact. If actual construction activities were occurring during that first encounter, avoidance or displacement actions might be magnified substantially, causing a change in the historical movement pattern.

Port site development at VABM 28 would result in direct habitat loss of approximately 20 ha (50 ac). In addition, storing the barge-mounted construction camp or the lighter in the breached lagoon would result in temporary or seasonal direct habitat loss of approximately 0.8 ha (2.0 ac). On a local basis, habitat loss could be significant for song birds, a few species of shorebirds, oldsquaws and dabbling ducks, as well as for small mammal species. Impacts would not be significant on a greater than local basis. For birds of prey and larger mammal species, direct habitat loss would not be significant even on a local basis.

Indirect habitat loss would not be of significance on a greater than local basis for song bird and small mammal populations as they would likely accommodate to the presence of the facilities and associated activities. Birds of prey and larger mammals, however, would generally tend to avoid the area. The degree of avoidance cannot be accurately predicted.

No raptor nests have been identified near this port site and no direct impacts on nesting would be expected. However, individual raptors, including peregrine falcons, have been sighted over the hills 4.8 km (3 mi) to the east. The presence of a developed port site would likely modify feeding behavior of raptors presently using the area.

Caribou and moose would not be significantly impacted by the presence of a port site at VABM 28. The important habitats for both species are generally located further inland, and only an occasional small group or individual would be likely to encounter the facility.

Bear and muskoxen could be impacted by indirect habitat loss on a local basis. Both species have been reported to use the area between the Mulgrave Hills and the coast as a movement corridor (Dames & Moore, 1983a). A facility at VABM 28 would likely interfere with normal northwest/southeast movements. Bears use the coast extensively, often moving right along the beach. The port facility with its associated noise and human activity would displace normal bear movements at VABM 28. In addition, the breached barrier beach could impede bear movements along the coast.

Bears, wolves, wolverines and foxes would also be impacted from disturbance and human contacts. While not significant on a greater than local basis, individuals would be displaced from the general area unless attracted by improper disposal of garbage or outright feeding. As described earlier for the mine area facilities, mitigation measures would include "bear-proof" fencing of garbage collection and incineration facilities, worker training in proper garbage handling techniques, and the removal of incineration residue and nonburnable wastes for burial in the tailings pond. Feeding of animals would be prohibited and this would be strictly enforced. All workers at the port facility would also receive environmental training.

Development of this site and use of the lagoon for lighter storage would not cause a significant indirect habitat loss for waterfowl. The lagoon and the immediate surroundings are relatively unproductive and few waterfowl appear to use the area, even during staging and migration.

Construction activities at the port site, aside from direct habitat loss, would have relatively little impact upon song bird, shorebird, waterfowl or small mammal species. However, construction would displace larger mammals to a greater degree than during operation of the facility. This would probably not be of greater than local significance except possibly for caribou. If the major autumn southeastward migration moved close to the coast during construction, a change in the historical movement pattern might occur.

Alternative 2

Construction of the northern corridor road would cause a direct habitat loss of approximately 257 ha (634 ac). While this would be approximately 60 ha (147 ac) greater than for the southern corridor road, direct habitat loss impacts for all species would be similar to those for Alternative 1.

Indirect habitat loss would also be similar to Alternative 1 for song bird and small mammal species.

The northern road corridor has more raptor nests than does the southern, including four peregrine falcon nests as opposed to three. All peregrine nests, however, would be at least 3.2 km (2 mi) from the road. The type of indirect habitat loss impacts upon raptors would be similar to those for Alternative 1, but the magnitude would be greater due to the higher number of raptors.

Indirect habitat loss for caribou would be somewhat greater than for Alternative 1 due to the greater length of the road. Chances of a significant interruption of historical caribou migration patterns would also be greater with the northern corridor road. Both the spring and early summer migrations would be more likely to encounter that road than the southern corridor road, with consequently greater risk of altering traditional routes.

Indirect habitat loss for bears would likely be greater than for Alternative 1. The Siatak Hills, immediately west of the Asikpak River, are important for denning, and movements to and from that area might be affected by the road. Also, as the road would parallel the river, road activities including human disturbance would displace bears using the Asikpak River for salmon feeding or other purposes.

Indirect habitat loss for moose would be greater than for Alternative 1, but would still be small. Road activity would tend to displace moose where the corridor crosses the riparian willow habitats favored by moose in winter. If not seriously disturbed by hunters, moose would likely accommodate to road activity associated with the project. There would be some mortality from vehicle collisions and stress caused by winter traffic.

Impacts upon muskoxen from indirect habitat loss would likely be similar to those for Alternative 1. While the Rabbit Creek herd would not be significantly affected by a road along the Asikpak River, one or possibly two small herds of muskoxen appear to range widely in the vicinity of the Singoalik River, the next drainage to the west.

Indirect impacts on waterfowl would likely be less than for Alternative 1. The northern corridor does not pass close to the same number or quality of small lakes, ponds and sedge-grass marshes used by waterfowl for molting and staging. Thus, disturbance by human activities, including hunting, would not be as great.

Direct habitat loss at Tugak Lagoon would total approximately 20 ha (50 ac). This would be the same area as at VABM 28, and the direct habitat loss for all wildlife species would be similar to that for Alternative 1. Impacts associated with the breached lagoon would also be similar to those for Alternative 1.

Indirect habitat loss at the port site for all wildlife would also be similar to Alternative 1 with the exception of bears and muskoxen. These species would likely be affected to a greater extent because of the presence of this port site in a much narrower and more restricted area between the coast and the first hills. Northwest/southeast movements could be displaced away from the coast.

Construction impacts would be similar to Alternative 1, except that the autumn northwest to southeast migration of caribou would probably not be affected.

Alternative 3

Terrestrial wildlife impacts would be similar to those for Alternative 1.

Groundwater Resources

Alternative 1

Potential impacts associated with a road along the southern transportation corridor would primarily involve the risk of groundwater contamination from fuel and chemical spills. Soils containing groundwater might then act as conduits for contaminant migration to nearby streams. Travel time between a spill site and a nearby stream would depend on the location of the spill, the substance spilled and the nature of intervening soil materials.

Potential groundwater impacts at the port site would also involve the hazard of fuel and chemical contamination. Spillage control plans and rapid response to spills would be the primary mitigative measures. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

Alternative 2

Groundwater impacts would be similar to those for Alternative 1.

Alternative 3

Groundwater impacts would be similar to those for Alternative 1.

Freshwater Resources

Hydrology and Water Quality

Alternative 1

Improper road construction techniques used on permafrost and across Arctic streams can lead to severe erosion problems and degradation of water quality downstream from stream crossings. If proper methods of road construction and drainage control were followed, environmental impacts could be held to insignificant levels. Under authority of Title 16 (Anadromous Fish Stream Permit), ADF&G must approve the design, construction and operation of any structure (e.g., bridge crossings, impoundment and drainage structures) that might affect an anadromous fish stream. This permit specifies certain stipulations that must be followed by the applicant to mitigate potential impacts. The Red Dog project would follow acceptable guidelines for road construction in the Arctic as summarized below. More specific detail on road construction, including design of all bridges and culverts, would be developed during the permitting phase of the project. The design, construction and operation of the road system would be in full accordance with agency permit stipulations.

The road would be constructed to protect the thermal regime. It would generally be composed of a 2.0 m (6.5 ft) deep layer of crushed rock or 0.6 m (2 ft) of crushed rock over 7 cm (3 in) of insulation. These specifications would prevent permafrost thawing and resulting severe erosion problems. Borrow sites would be located to minimize potential water quality impacts on local drainages. Buffer strips and sedimentation ponds would be used at borrow sites located within 91 m (300 ft) of surface waters to protect water quality. Borrow excavation operations at surface gravel sources would be conducted so that the resulting contoured edges could be revegetated using appropriate Arctic techniques. Where natural gravel sources were not available, rock quarries would be developed by drilling and blasting operations. The side slopes of the quarries would be made to resemble surrounding rock outcrops. Natural freeze-thaw cycles would eventually erode the surface of these side slopes to create a natural scree* cover. Depressions resulting from gravel and rock extraction would be allowed to fill with water to form ponds or lakes.

---

* Defined in Glossary.

Haul roads for construction materials would receive special attention due to their temporary nature and potential for tundra and permafrost damage. These roads would be built to have a stable wearing surface appropriate for the time of year. Whenever possible preliminary construction work would be done in the final road alignment. Construction using snow roads or rolligons* would occur during winter months. Off-road construction activities during the thaw season would normally occur where exposed rock surfaces, finished gravel roads or gravel pads would be available as staging areas. Construction on areas of ice-rich soils and wet areas would be avoided during the thaw season.

The number and types of stream crossings required for the transportation corridor alternatives are shown in Table V-14.

Temporary stream diversions during construction of crossings would be designed to minimize erosion and sediment loads. Stream crossings would be surveyed for bank stability, stream character, icing occurrence and ice jam potential. Scour and erosion risk would be evaluated at all stream crossings. If bank excavation for bridge or culvert installation would expose ground ice, the exposure would be covered with an insulating layer of synthetic material, soil, gravel or rock.

Emphasis would be placed on minimizing clearance of vegetation and disturbance of soils. Erosion control measures would include revegetation, mulching, mat binders, solid binders, rock or gravel blankets and terracing. Special problem areas would be associated with exposed ice or ice-rich slopes. Areas of natural accumulation of winter icings would be completely avoided. Care would be taken that the road embankment not restrict cross-drainage of surface or groundwater. Improper drainage could create impoundments behind the structure and result in destroyed habitat. Slope drains and minor stream crossings would be designed to prevent hydraulic or thermal erosion by use of channel liners, rock aprons, check dams and energy dissipators.

Along the corridor there would be potential spill hazards due to transportation of mill process chemicals, diesel and fuel oil and ore concentrates. The greatest risks to the environment would be from spills of toxic chemicals near stream crossings. The most serious spill would be from an oil tanker truck/trailer because of the potential large volume of oil involved. Spillage control plans and rapid response to spills would be the primary mitigative measures. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

Alternative 2

Major bridges on the northern corridor would be required at Ikalukrok Creek, Main Fork Wulik River, West Fork Wulik River, Grayling Creek,

---

* Defined in Glossary.

Table V-14

ESTIMATED NUMBER AND TYPE OF STREAM CROSSINGS REQUIRED FOR SOUTHERN AND NORTHERN TRANSPORTATION CORRIDORS

	Southern Corridor	Northern Corridor
Length of road	89.9 km (56.2 mi)	117.0 km (73.1 mi)
Major bridges[1]	1	6
Minor bridges[2]	4	6
Major culverts[3]	49	81
Minor culverts[4]	133	219
Total stream crossings	187	312
Icing locations at culverts	14	24
Fish passages at bridges and culverts	11	12

Source: Cominco Alaska, Inc.

[1] Bridge span $\geq$30.5m (100 ft).

[2] Bridge span <30.5 m (100 ft).

[3] Culverts $\geq$ 137 cm (54 in) diameter, or the equivalent of using two to three smaller culverts.

[4] Culverts <137 cm (54 in) diameter at gullies, grassy swales and seasonal drainages.

Kivalina River and Asikpak River (Fig. II-6). In comparison, the southern corridor would have only one major bridge (across the Omikviorok River). With the exception of the Asikpak River, bridges on the northern road would cross wide meandering or braided rivers with unstable banks. Protection of these crossings from excess generation of sediment during construction and high flows would be difficult. Icings and ice jams in these rivers would also place unusual engineering constraints on design. The northern route would have nearly twice as many minor culverts and more difficult icing and fish passage problem crossings. Due to the number of stream crossings which pose engineering difficulties, the northern route would have much greater potential for significant environmental impacts related to increased stream sediment loads and the risk of hazardous chemical spills reaching streams.

Alternative 3

Hydrology and water quality impacts would be similar to those for Alternative 1.

Biology

Invertebrates

Alternative 1

The southern corridor would cross approximately 187 streams primarily with culverts. One major bridge would be constructed across the Omikviorok River. Twenty-four of the streams would have gravel/cobble substrates and 18 grassy swales would be crossed. Benthic production would be lost at stream crossings and downstream of crossings during construction as a result of instream work and sediment production. This would be a transient loss, generally of less than one week. Longer term losses could result from erosion of altered stream banks unless they were revegetated. The amount of loss would depend on construction timing relative to insect life cycles. The loss would not be significant overall since a small portion of total stream length would be affected.

A small permanent loss of habitat would occur as a result of culverts replacing natural substrates. This loss would be negligible compared to total stream lengths and would not be expected to significantly affect fish production. Provided culvert size were sufficient to allow spring gravel flushing, and ongoing erosion were small, no additional impacts would be expected. Loss of production would occur if ore concentrate or fuel spills occurred.

Alternative 2

The northern transportation corridor would cross approximately 312 streams with six major bridges, six minor bridges and 300 culverts (Fig. II-6). Thirty-two of the streams would have gravel/cobble bottoms and 17 grassy swales would be crossed. Construction impacts would be similar to those for Alternative 1. However, greater impact would result due to the larger number of crossings and the greater amount of instream work required at the six major bridge crossings.

Permanent impacts would occur in the same manner as those for Alternative 1. However, more streams would be crossed, so more habitat loss would occur. Impacts on trophic* resources would not be significantly greater since a similar number of streams containing fish would be impacted.

---

* Defined in Glossary.

Alternative 3

Benthic invertebrate impacts would be similar to those for Alternative 1.

Fish

Alternative 1

The southern transportation corridor would be approximately 89.9 km (56.2 mi) long and would cross approximately 187 streams ranging in size from rivers to ephemeral drainages (Table V-14). Eleven of these streams are known to contain fish (Fig. IV-9). Five tributaries to the Wulik River would be crossed in their headwaters, well away from the main stem of the river. Four of these tributaries support fish (Arctic char and/or Arctic grayling) in the vicinity of the corridor crossings during the summer months (Dames & Moore, 1983a). All four tributaries provide some fish spawning habitat near the corridor crossings.

The Omikviorok River would be crossed at least once on three of its five forks and once on the upper part of the main stem. The river provides spawning and rearing habitat for char in its lower reaches. Tributaries to the Omikviorok River would also be crossed, but none of these tributaries is known to contain fish in the vicinity of the transportation corridor crossings. New Heart Creek would also be crossed in its upper reaches and is known to contain Arctic char near its mouth.

Both the Omikviorok River and New Heart Creek flow into Ipiavik Lagoon where some subsistence fishing occurs. These systems are less critical than the Wulik and Kivalina River drainages, but should be afforded the protection of proper crossing site selection, crossing design and construction timing.

Potential impacts from road construction and operation along the southern corridor would involve an increase in sediment loading, fish migration barriers, risk of spills to major water courses and increased access to currently inaccessible areas. Minor increases in sediment loading would be unavoidable during construction and operation of the road in spite of mitigation measures. Impacts on fish from sediment originating from the road could be minimized to insignificant levels by good crossing location selection, proper crossing design and construction timing. Crossings where fish were present or where migration occurred should have crossing structures that do not impinge on the floodplain area.

Preliminary detailed information on the amounts of materials and locations of borrow sites along the entire corridor is shown in Table II-3. Borrow sites would be located as far from water courses as possible to minimize surface runoff impacts. However, in cases where the borrow sites were within 91 m (300 ft) of surface waters, provisions would be made for the collection and settlement of suspended solids from runoff water. Provided these precautions would be taken, borrow site impacts on fish resources should be small.

If borrow material was taken only from sites outside Cape Krusenstern National Monument, the surface area and excavation depths of Sites 7 and 8 would increase (Table II-4). Because Site 8 is located within 91 m (300 ft) of a stream, potential impacts to fish from borrow site expansion might become significant unless further protective measures were taken.

The transportation of concentrate and chemicals along the road poses a risk of undetermined probability. The scenario of spillage directly to a stream poses the most serious hazard. Spillage control plans and rapid response to spills would be the primary mitigative measures. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

Timing of construction for crossings along the transportation corridor should consider the individual stream. For streams without fish, the crossing could be made at any time, but caution should be exercised to prevent as much disturbance and sediment generation as possible. Streams containing fish could be crossed with minimum impact after Arctic grayling fry emergence in about mid-June, but prior to Arctic char and salmon spawning in late August.

Alternative 2

The northern corridor would be approximately 117 km (73.1 mi) long and would cross about 312 streams ranging in size from rivers to ephemeral drainages (Table V-14). Three major drainages (Wulik, Kivalina and Asikpak Rivers) would be involved along with four minor drainages. The Wulik River drainage would have approximately 28 stream crossings, four of which would be on the main stem or main forks. Fish are present at all of the major crossings. Three of the 24 smaller tributary streams also contain fish. The Kivalina drainage would experience about 23 crossings, three of which would be main stem or main fork crossings. These three crossing areas all contain fish, whereas the 20 tributary crossings contain no fish (Fig. IV-9). The Asikpak River drainage would have 13 stream crossings. One of these crossings would be on the main stem near the river mouth where fish are present. Only one of the 12 tributary streams to be crossed contains fish.

Between the Asikpak River and Tugak Lagoon four other drainages would be crossed. These are small drainages which do not contain fish. Two of these drainages enter Asikpak Lagoon; another enters Kavrorak Lagoon; and the other flows directly to the sea.

Potential impacts to fish from road construction and operation would be similar to those for Alternative 1, but of a significantly greater magnitude due to the greater number of crossings of important habitat. The northern corridor would cross the major fish streams in the project area (the Wulik and Kivalina Rivers and tributaries) at several locations. These streams are very important for spawning, rearing and overwintering fish and as such are also migration corridors. Proposed crossings occur in main stem areas and in significant and highly sensitive char spawning areas in both drainages. Several of these crossing areas have highly unstable and very mobile stream beds where lateral movement occurs readily. It would be particularly difficult to ensure that crossings in these areas did not cause barriers to fish migration. The design of appropriate crossings to prevent migration barriers and allow crossing stability would require considerable effort. Proper crossings in these areas would be critical since any migration blockage of main stem areas would eliminate large sections of spawning and rearing areas used by Arctic char and Arctic grayling.

The increase in access available to local residents or mine employees would adversely impact fish resources in streams that are crossed by the corridor. These impacts would result from fishing and associated disturbance during the late summer char spawning period, and could severely impact char populations in the Kivalina drainage. Other impacts such as sediment from construction and borrow pits, concentrate spillage, and timing and location of crossings would be similar to those described for Alternative 1, but of a significantly greater magnitude because of the higher number of major stream crossings.

Alternative 3

Fish impacts would be similar to those for Alternative 1.

Marine Biology

Marine Invertebrates and Fish

Alternative 1

Port site construction activities would result in increased suspended sediment and turbidity in neighboring waters. Port Lagoon, located adjacent to the port site, would be breached to shelter a barge-mounted construction camp. Some dredging could take place along the shore depending on the local availability of fill, but no dredging would take place within the lagoon. The short causeway construction would involve driving or vibrating sheet pile, placing of armor rock and the placing of fill.

In open water areas, the suspended sediment resulting from construction would be dispersed by wind and waves. Sessile organisms, including polychaete worms, gammarid amphipods and ophiuroid seastars, would be smothered in areas of high sedimentation. More mobile organisms such as shrimp, crabs and fish would abandon the area. Construction impacts would last approximately one season.

Breaching Port Lagoon would result in saltwater intrusion, with insect larvae slowly replaced by euryhaline* crustaceans (isopods, amphipods and mysids), molluscs (bivalves and gastropods) and oligochaete worms. Euryhaline fish species which might also penetrate the breached lagoon could include Arctic flounder, starry flounder, Pacific herring, and anadromous species such as humpback whitefish and pink salmon. The lagoon would, therefore, become more similar to other open lagoons on the coast. These lagoons generally have greater fish and invertebrate species diversity than closed lagoons, and appear to be more productive. Although local impacts from breaching would be significant, they would be of a short duration, and a relatively more stable saline lagoon environment would result. Impacts would not be significant on a greater than local basis because of the large number and area of coastal lagoons (207 km^2 [80 mi^2]) between Cape Krusenstern and Point Hope.

---

* Defined in Glossary.

Additional construction impacts would result from heavy equipment moving over shallow subtidal areas; vibrations from pile driving and rock placement; oil and gas spills and leaks from construction equipment; and possible dredging. With the exception of dredging, these impacts should not add significantly to the impact of suspended sediment and turbidity increases. Dredging impacts would depend upon the amount of area dredged and the water depth. Dredging from greater depths would result in the loss of a larger number and biomass of organisms than shallow depths.

Construction of the short causeway would remove approximately 0.9 ha (2.2 ac) of shallow subtidal and intertidal habitat. Densities of infaunal* organisms range from 16.7/m^2 (1.6/ft^2) (Dames & Moore, 1983b) to 266.6/m^2 (24.8/ft^2) (Dames & Moore, 1983a). The infauna is characterized by nematodes, amphipods, polychaetes and tunicates. Approximately 66.2 to 77.6 kg (146 to 171 lb) (Dames & Moore, 1983b) of organisms would be lost. Epifauna* (typically gammarid amphipods, mysid shrimp, seastars and crabs) would be displaced and habitat for foraging bottomfish would be lost.

The short causeway would add hard substrate habitat in the form of armor rock and sheet pile. The armor rock (approximately 0.3 ha [0.7 ac] nominal surface area) would provide habitat for hard substrate organisms such as barnacles, shrimp and gammarid amphipods. Exposed hard faces (sheet pile and exposed armor rock) would only provide seasonal habitat due to ice scouring.

Sediment would generally be deposited on the northwestern side of the causeway structure and eroded from the southeastern side, though at some point in the future an equilibrium would be reached. Infauna and epifauna communities would be altered by these erosional and depositional patterns, but it would be impossible to predict overall effects.

Construction of the transfer facility would have a minimal impact on anadromous and marine fish. There would be a possibility that fish moving along the shore could be impeded by the causeway, but its short length would not likely cause a substantial barrier to migration. The causeway should be constructed in July or early August to prevent any interference with migrating fish that could be caused by sediments or noise.

Construction of the offshore island transfer facility would require initial dredging followed by placement of berms on which the tanker would rest. Once in place, dredged sediment would be pumped into interstices beneath the ship. Dredging for site preparation would impact about 24 ha (60 ac) of bottom. The density of infaunal organisms in this area ranges from $3.1 \times 10^6/m^2$ ($2.9 \times 10^5/ft^2$) to $7.9 \times 10^9/m^2$ ($7.3 \times 10^8/ft^2$) and biomass from 0 mg/m^2 (0 mg/ft^2) to 785.5 mg/m^2 (73.0 mg/ft^2). This means approximately 90.5 kg (200 lb) of biomass would be removed. Affected species would include polychaete worms, bivalves, gammarid amphipods, crangon shrimp and ophiuroid seastars.

---

* Defined in Glossary.

Dredging operations would also create suspended sediment and turbidity. A reduced infauna and epifaunal community would result from this, and fish would tend to avoid the area. These impacts would be significant on a local basis, but not on a greater than local scale. Turbidity and suspended sediment impacts would cease shortly after dredging stopped. Recolonization would occur within the next growing season. Transient impacts would also likely result from small fuel and motor oil leakages or spills.

Once in place the offshore island would result in the loss of approximately 24 ha (60 ac) of soft bottom benthic habitat. Although the submerged sides of the ship would represent new hard substrate, attached community development would be reduced by ice scouring. An increase in deposition would tend to occur on the northwestern side of the ship and increased erosion would tend to occur on the southeastern side. This might result in some alteration of the biotic communities, although the changes would probably not be significant.

During construction and operation, fuel, chemical and ore concentrate spills might occur. These could occur on a small continuing basis or from a catastrophic event. In either case, some toxicity would result. The amount of toxicity would depend on the size of the area affected, as well as on the type and concentration of toxicants. Small spills would have a locally significant impact, but would probably not be significant on a greater than local basis. Larger spills could have greater than local impacts on fish and invertebrate populations. Spillage control plans and rapid response to spills would be the primary mitigative measures. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

The offshore island transfer facility would have little effect on nearshore fish and invertebrate migrations. The tanker would be approximately 1,097 to 1,219 m (3,600 to 4,000 ft) from the shore in 7.6 m (25 ft) of water at its shoreward end. This should be ample space for the movement of mobile species. Movement in deeper water seaward of the facility would be unimpeded.

The offshore island should not negatively affect fish resources but might, in fact, act as an artificial reef for orientation and attachment of food organisms.

Alternative 2

Overall impacts would be similar to those described for Alternative 1, although the density and diversity of benthic organisms appear to be greater than at the southern port site. The benthic community assemblage also appears to be composed of longer-lived species rather than short-lived, opportunistic species as found at VABM 28.

Construction related impacts to nearshore invertebrate communities at Tugak Lagoon might include a community shift towards shorter-lived, colonizing species typical of shallow water habitats. Eventually, a longer-lived community would return after disturbance ceased. The port site would remove approximately 72 kg (159 lb) of biomass, while the offshore island ship would remove about 90.5 kg (200 lb).

The construction and operation of the port site facility at this site should have no adverse effects on fish provided that oil, chemical and concentrate spills were contained. Some sediment loss to the environment might be expected, especially during construction. However, no anadromous fish spawn or rear in the vicinity of Tugak Lagoon so no impact would be expected. The lagoon would be breached for storage of construction and lightering barges, but this should have no impact on anadromous fish since the lagoon is not used by these fish. Other species of marine fish would likely be affected by modification of the lagoon in a manner similar to that described for Alternative 1.

Impacts of the short causeway and offshore island would be similar to those for Alternative 1. The offshore island might provide suitable substrate for herring spawning thought to occur in this area. This could have a beneficial effect on herring stocks if spawning habitat is presently limited.

Alternative 3

Port site and lagoon impacts would be similar to those described for Alternative 1. There would be less removal of benthic habitat and generally less dredging activity because no offshore island would be constructed. Elimination of the offshore island transfer facility would increase the risk of a chemical or concentrate spill. Transfer of concentrates would be more likely to occur in the limited time frames when the bulk cargo carriers were present, even if weather conditions were unfavorable. The direct effect of a spill on fish would depend on the time of year (i.e., during migratory or nonmigratory periods) and on the nature of the spilled material. Impacts on both anadromous and marine species could range from low to moderate.

Marine Birds and Mammals

Alternative 1

The persistent polynya that typically forms offshore between Kivalina and Point Hope would likely attract greater use by marine mammals, including endangered whales, and marine birds. Therefore VABM 28 as a port site location, approximately 26 km (16 mi) southeast of Kivalina, would likely have less general impact upon these groups than would a port site at Tugak Lagoon located closer to the polynya.

Direct habitat loss from construction of the short causeway and ballasted ship would total approximately 24.9 ha (62.2 ac). This would not be a significant loss to either marine birds or mammals.

Indirect habitat loss for marine birds would not be significant as they do not use the nearshore areas for feeding. For marine mammals indirect habitat loss could be significant, but probably only on a local level. There might be some displacement of ringed seal pupping in late March/early April, but this would be very local in nature. The noise and activities associated with lighter and bulk carrier traffic, and the corresponding loading and unloading activities at the short causeway and the ballasted ship, would cause marine mammals to generally avoid the area. Neither the causeway nor the ballasted ship would present a physical obstacle to movements.

The endangered bowhead and Gray whales exhibit excellent hearing and respond to sounds caused by human activities. Whales demonstrate avoidance reactions to ship and helicopter noise at distances of 1.6 to 3.2 km (1 to 2 mi). While some noise and disturbance would occur year-round, most disturbance would occur during the ice-free shipping season from late June until early October. The bowhead whale in particular is slow-moving, timid, and sensitive to sound. Bowhead whale migrations from mid-April to early June would be unimpeded as most individuals move well offshore. However a few moving closer to shore might be displaced seaward of the facilities to some extent by noise. Any significant noise-generating activities on the dock or on the ballasted ship would be restricted during the April through early June whale migration period to keep impacts to bowhead whale migrations past Kivalina to a minimum. The autumn return migration of bowheads is usually well offshore to the west in the Chukchi Sea. The Gray whale, which normally moves and feeds nearshore, would likely avoid the port facilities also, thus reducing feeding habitat to some extent.

Initial vessel traffic associated with the port would be low, approximately 16 to 20 bulk ore carriers, tankers and supply ships per year. These vessels would be active only during the ice-free shipping season from late June to early October and would not overlap the normal bowhead whale migration period. The small number of vessels would probably not significantly impact any marine birds or mammals.

Transfer facilities construction would have essentially the same kind of impacts as described for indirect habitat loss above, but of a greater magnitude. Disturbances from driving sheet pilings, rock filling of the short causeway, dredging and ballasting the ship could cause significant local displacement of marine mammals. If these activities occurred during northward bowhead whale migrations from mid-April to early June, there might be displacement of individuals seaward of the facilities. Following completion of construction, noise and disturbance levels would decrease to those of ongoing operation.

Transfers of concentrates from the short causeway to the lighter, the lighter to the ballasted ship, and from the latter to the bulk carriers would create an unknown risk of spillage, as would movement of petroleum products, reagents and other toxic materials in the opposite direction. Chronic spillage or a severe spill could have significant impacts on both marine birds and mammals, depending upon the time of year and local weather conditions. The stable nature of the two platforms at each point of transfer (i.e., the short causeway and the ballasted ship) would tend to lower the probability of such spills. The buried pipeline from the ballasted ship to the short causeway would also lower the probability of petroleum spills.

Alternative 2

Because of the polynya which forms offshore between Kivalina and Point Hope, the Tugak Lagoon port site in this alternative would likely have a greater general impact upon marine birds and mammals than would a port site at VABM 28.

Impacts associated with the short causeway and ballasted ship transfer facility would be similar to those for Alternative 1.

Alternative 3

Impacts associated with construction and operation of the port site facility would be the same as those for Alternative 1.

Direct habitat loss from construction of the short causeway only would total approximately 0.9 ha (2.2 ac). This would be approximately 24 ha (60 ac) smaller than Alternative 1, and would not be a significant loss to either marine birds or mammals.

Indirect habitat loss for marine birds would be similar to that for Alternative 1. For marine mammals it would likely be less. For this alternative the peak periods of activity and disturbance would be limited to approximately 16 to 20 times during the ice-free shipping season when the lighters would directly load or unload the bulk ore carriers, tankers or supply ships. In Alternative 1, there would be more constant activity offshore as concentrates were steadily moved to the ballasted ship and routine maintenance and operations generated noise.

Transfer facilities construction would have somewhat less of an impact than Alternative 1 because there would be no dredging or ballasting of the ship. However, this would not likely be a significant difference.

To the extent marine birds and mammals would be affected by concentrate and other toxic spillages, this alternative would likely have a greater impact than Alternative 1. The lack of a stable concentrate transfer platform during periods of rough weather, as would exist with the ballasted ship, would increase the probability of chronic or major spills. Also, petroleum products would have to be transferred to the short causeway by lighters, and not through a buried pipeline. This would also increase the risk of spills.

Physical and Chemical Oceanography

Coastal Geologic Processes

Alternative 1

According to Hopkins (1977), the net drift of the sediments in the area of the proposed port facility at VABM 28 is to the southeast. Moore (1966) estimated that approximately 22,000 m^3 (28,780 yd^3) of sediment move down the coast to be deposited at Sheshalik Spit each year. However, Woodward-Clyde (1983) recently estimated that about 82,580 m^3 (108,000 yd^3) of sediment is transported annually.

It would be extremely unlikely that Cape Krusenstern would be affected by a sediment barrier 32 to 48 km (20 to 30 mi) away since: (1) large volumes of sediment, compared to potential trapped sediment, exist between the VABM 28 port site and the Cape Krusenstern beaches; and (2) the entire coastline is eroding and providing an ample sediment source. Placement of a solid causeway at either port site would affect areas limited to a distance of approximately eight to 10 lengths of the structure. Local and offshore sediment sources exist which would compensate for the trapped sediment. The total maximum sediment entrapped by the causeway would be about 183,500 m^3 (240,000 yd^3) (Woodward-Clyde, 1983), though the actual amount trapped would probably be closer to 137,630 m^3 (180,000 yd^3). Because total entrapment is approximately 1.7 to 2.2 times the yearly sediment transport, it would take about one and a half to two years for sediment to begin bypassing the causeway structure. This would have only local impacts.

The port site causeway would have an effect on the beach adjacent to the causeway. The up-drift (northwest) side of the causeway would temporarily fill in and stop sediment movement. Erosion would occur on the down-drift (southeast) side of the causeway, and would be approximately equal in volume to the sediment trapped on the up-drift side. The impacts would be significant locally, but would represent an insignificant percentage of the total volume of sediment moved toward Cape Krusenstern southeast of the port site.

Construction of a breached causeway was initially considered as a means of reducing local down-drift erosion. Although a breached causeway would allow more net sediment movement along the shore (and thereby reduce local erosion impacts), such a causeway would be technically more difficult to construct and maintain, and was, therefore, not considered to be cost effective. Neither causeway would affect sediment movement on a greater than local basis.

Storms can produce waves that would cause sediment movement in either direction along the coast. The amount of material moved by such storms could be as large as the net sediment transport for the year. Therefore, alternate erosion and filling would be expected to take place on either side of the causeway. The erosion could also threaten portions of the port facility if they were not properly protected. On the up-drift side of the causeway, where sediment would be deposited, the effect would be to alter the depth of water and composition of the nearshore substrate. This could have a local impact on the marine organisms as previously discussed.

The effect of the causeway on the beach ridges at Cape Krusenstern, 38 km (24 mi) to the southeast, would be insignificant since the main impact of erosion would be near the causeway. Material would fill the area on the northwest side of the causeway, and would then begin passing around the causeway to the southeast to maintain the net transport rate. Most of the material traveling to the Monument originates down-drift of the VABM 28 port site (Hopkins, 1977).

An offshore island would have little or no effect on sediment transport along the coast because, in the depth of water at the island, wave-induced water velocities and wave force impacts on the bottom which are the primary forces in sediment movements would be smaller than near the shore. The reduced forces on the bottom sediments would tend to move only the finer-grained materials. The amount of material moved at the depth of the offshore island would, therefore, be insignificant compared to the material moved along the beach.

Alternative 2

The forces acting to move material along the beach at this port site would be different than the forces acting at the VABM 28 port site. The effects of deposition and erosion in the area adjacent to the causeway would be approximately the same as those at the VABM 28 port site, except that the net movement of sediment would probably be to the northwest.

At this site the nearest lagoons (Tugak and Kavrorak) would be at least 1,050 m (3,452 ft) distant from the causeway. Because of this separation, the only likely effects of the causeway would be erosion and deposition adjacent to the port facility. This could endanger the port facilities if they were not properly protected. The composition of the substrate in the vicinity of the causeway would also be changed, but this would only be of local significance. There would be no effect on Cape Krusenstern since several sediment nodes exist between this location and Ipiavik Lagoon (Hopkins, 1977).

Alternative 3

Coastal process impacts would be similar to those for Alternative 1.

Marine Water Quality

Alternative 1

Port site construction could increase sediment loading for a short period until a beachhead were established. During construction and operation, the lagoon barrier beach would be breached for barge access to the lagoon. Sediment impact of limited beach construction would not be significantly different from that experienced during summer storms which move considerable quantities of beach sediments. Impacts would be local.

Onshore port construction activities could cause erosion and sediment contaminated runoff into the marine environment. Sedimentation ponds to capture and treat runoff would be constructed early in the schedule to limit impacts on marine water quality.

Offshore construction impacts would be comprised of limited sediment increases during the short causeway construction and seabed preparation for the ballasted tanker. The short causeway would be comprised of sheet piling facing with backfill from the shore out to the piling. Sedimentation would be limited by the piling facing. Excavation of fill material would increase local sediment loading for a short time period. No significant long-term water quality impact would result.

Seabed preparation for the ballasted tanker would require dredging and placement of bottom material in an approximate 61 × 305 m (200 × 1,000 ft) area to accommodate the ship. Granular material would be pumped under the ship to give uniform support, and the tanker's outer holds would be ballasted with approximately 72,628 m^3 (95,000 yd^3) of granular material. The granular material would be dredged from the seabed adjacent to construction sites.

Excavation and placement of the bottom and ballasted material would resuspend small sediment fractions of the existing seabed. There is evidence that such resuspension occurs regularly during summer storms. Construction activities would not be significantly different and would produce no long-term water quality impact. Corps guidelines would be followed for dredge and fill operations.

Wave-induced scour of ocean bottom sediments has been noted in 9 m (30 ft) water depths. Observations of the project area seabed indicate signs of such movement. During storm events it is not uncommon to have design waves in the area exceeding 6 m (20 ft) in height. Such waves might induce a velocity along the seabed in excess of 1.8 to 2.4 m/s (6 to 8 ft/s). A ship ballasted in place and exposed to such waves would experience wave forces and velocities in excess of the normal bottom velocities. The design of the ballasting system should be such that wave forces and velocity would be considered. Appropriate design considerations along the boundaries of the ballasted ship would be necessary to control scour and to protect the ballasted tanker foundation. The design evaluation process must address scour causes, anticipated scour effects and methods of scour control. The design wave selection should consider events likely to occur during the life of the mining activity. Proper design features would limit the potential of impacts due to sediment movement or ship damage.

The tanker would also be designed to withstand anticipated forces from ice movements. The tanker would have a sidewall height of 24 to 27 m (80 to 90 ft) and be ballasted down in 9 to 12 m (30 to 40 ft) of water to provide a freeboard of approximately 12 to 18 m (40 to 60 ft). Limited experience with a similar structure in the Beaufort Sea (Dome Petroleum's structural steel drilling caisson) indicates that ice override of the ballasted tanker might not be a problem. Reports show that the ship essentially creates a barrier to ice movements and the resulting ice pile-up builds against the ship, grounds out, and forms its own rubble field of protective ice. This effect is expected to provide adequate protection from wind-driven ice impacts on the ballasted tanker. The added ice strengthening steel plate around the waterline of the ship, and the additional internal bulkhead bracing, would be designed to withstand anticipated ice forces. An ice load monitoring system would also be installed in the hull.

Detailed design engineering for the ballasted tanker concept has not been performed to date and is beyond the scope of this document. Detailed and very complex design efforts including modeling of scour and ice forces might be necessary for full evaluation. Little experience exists with similar facilities so it is impossible to statistically evaluate the probability of various risks associated with the ballasted tanker. Detailed designs would consider potential risks and address safety factors that could reduce risks to acceptable levels. Such design detail would be included in pertinent state and federal permit applications.

Other potential marine water quality impacts involve shipping and material handling spill risks. The risk of spill of fuel and materials might be somewhat higher during construction. However, the quantities of material and frequencies of shipments during operation would present a much higher overall risk. Since spill risk analysis is a statistical problem that has not been quantified, the impacts for construction will be discussed along with operational impacts.

Spillage during construction or operation could result from transfers between the "ship island" and lighter barges, or between lighter barges and the short causeway (and vice versa); shipping accidents; or weather related hazards. During construction, the items that would be most likely to result in a spill problem would be fuel, cement and concrete additives and oil. Spillage during operation could include fuel, ore milling process chemicals and concentrate. Impacts from spill events would vary depending upon the magnitude of the spill and the material spilled. The area of impact would vary depending upon the weather conditions (wind, waves and currents).

Impacts of fuel or oil spills could be heavy on local area aquatic life. Overall water quality impacts would be short-term for small spills, but major spills could have greater than local significance and result in longer term hydrocarbon-induced water quality degradation. Under adverse weather conditions, oil spills could impact beaches anywhere in the area from Cape Krusenstern to Point Hope.

On an annual basis, approximately 214,000 bbls of fuel oil would be consumed by project power generators, on-site equipment and for regional fuel use by villages. A year's supply of fuel would be stored primarily in the ballasted offshore tanker. Oil to be stored on the tanker would be transferred from bulk carriers using flexible hoses. Transfer would be rapid and the primary spillage potential would be on the ships where hose connections would be made. Spillage on the ship should be contained onboard.

Onboard fuel storage and handling facilities would be in center compartments protected from the sea by two layers of steel (Fig. II-17). Containment capacity in the tanker would be 10 percent above the projected necessary storage volume. Large protective wing tanks on either side of the fuel storage tanks would contain gravel ballast material, thus providing a considerable degree of protection from side impacts. Status monitoring of the stored fuel would be continually conducted by instrumentation, and the bilges between hull compartments would be routinely inspected.

Transfer of fuel from the tanker to shore would be through a buried 10-cm (4-in) diameter steel pipe surrounded by a 15-cm (6-in) diameter steel guard pipe. Flow detectors would be used to monitor fuel transfer operations to give immediate indication of pipeline leakage or unusual transfer conditions. As an extra precaution, a fuel leak detection system would be installed to detect leakage from the 10-cm (4-in) transfer pipe into the space between the two pipes.

To preclude the possibility of pipeline break impacts, the transfer pipeline should be purged of fuel oil between transfers. An oil spill under ice or in open water could have significant impacts on fish and wildlife if unnoticed and not immediately reclaimed. Fuel oil spills under ice would be especially harmful unless quickly detected because they could not be effectively cleaned up. With proper design, construction and monitoring, the buried pipeline with associated leak detection systems could be installed and operated in a manner which would minimize the potential for fuel oil spills occurring during fuel transfer operations.

Onshore fuel storage tanks would be constructed on well drained gravel pads or on pilings, with spillage containment dikes and synthetic liners constructed around the tanks. Trucks would be used to transfer oil to the mine site. Truck transfer areas should be constructed to drain to spill containment areas, and should be sealed to prevent undue soil contamination.

Spills of mill process chemicals that disperse or dissolve in seawater could result in buildup of toxic concentrations in the immediate area of the spill. Process chemical spills could be extremely significant. Chemicals such as sodium cyanide, copper sulfate and sulfuric acid could result in direct toxic reactions and degradation of surrounding water quality to below aquatic life standards. Depending upon weather (wind, wave, current) conditions, the toxic area would be dispersed in hours or days. Impacts of small spills would be locally significant, while large spills could have a greater than local significance.

Potential for spills at the port site would be low because all unloading, handling and storage of concentrates would be done under cover in an enclosed area. Conveyors would be covered to protect against wind pick up of concentrate particles, and the structural supports at conveyor transfer points would be skirted at the bottom to contain any minor spills which might result during handling operations. These spills would be cleaned up and returned to the storage building.

The port site area would be served by drainage collection channels and a sedimentation pond to control suspended particulate matter generated by runoff erosion. This system would also be able to contain miscellaneous spills of concentrates or fuel oil which were not controlled at the source. Accumulated water in the onshore containment system would require treatment and discharge during the summer months to maintain adequate storage volume in the event of a fuel tank rupture. Any contaminated sediment which was collected in the pond would be reclaimed and transported to the mine site for disposal in the tailings pond. Annual sampling of site materials and pond sediments would be conducted to determine concentrations of lead, zinc, barium, cadmium and fuel oil which might accumulate due to spills and normal operations.

The primary source of potential concentrate spillage to the marine environment would be during the dock/lighter/tanker/bulk carrier loading and unloading operations. All points of material transfer for this alternative would be relatively secure. The dock transfer and two ballasted ship transfers would be stable, and would occur in protected conditions using conveyors or cranes operating from a stable platform. It would be expected that at some point weather might be a significant factor in the environmental safety of loading operations. All loading and unloading would be suspended during extreme wind and sea conditions.

The lead and zinc concentrates would be essentially sulfides of the respective metals, while the barium concentrate would be barium sulfate. Sulfides are insoluble and release toxic contaminants very slowly upon prolonged exposure to the elements. If submerged under most marine or freshwater conditions, they would be expected to remain intact and not oxidize to the corresponding soluble metal sulfates over short time periods of days or months. However, upon dilution and mixing with water, some initial release of surface adsorbed flotation reagents would occur. Impacts would be of low to moderate local significance.

Most reagents used in the milling process have been evaluated for toxic impacts by Hawley (1972). The impacts at low concentrations are significant for many of the reagents. The quantities anticipated in the event of a spill and the short exposure would not present a significant long-term impact, however, rapid implementation of cleanup measures would be necessary. In the event of a soluble material spill, dispersion and resulting dilution would reduce the significance of local impacts.

Barium sulfate has a low water solubility of about 2 mg/ℓ and is not regarded as being particularly toxic. Quantities released to the environment would depend on the degree of contact with water and the duration of exposure. Therefore, mitigation in control of concentrate spills would require rapid implementation of cleanup measures where practicable.

The impact of a concentrate spill would also depend upon quantities and weather conditions. Small spills during ship transfers would be dispersed rapidly and would not cause even a short-term impact. Small spills which occurred repeatedly over years of operation could increase sediment concentrations of lead, zinc and barium. Present sediment concentrations for these elements are as follows:

Sediment Concentrations at Port Sites	
Lead (Pb)	2.7 to 6.3 mg/kg
Zinc (Zn)	25 to 46 mg/kg
Barium (Ba)	22 to 283 mg/kg

Spills of 0.9 Mg (1 ton) of concentrate per day would be anticipated to increase sediment concentrations spread evenly along an 8 km (5 mi) segment of the coastline approximately one percent in 20 years of operation. Concentrations near large spill sources could approach pure concentrate strengths. However, mixing energy and sediment transport would be strong influences. The high inherent mixing energy and fine concentrate grind would tend to disperse concentrate spills. The slowly settling concentrate would create suspended solids water quality impacts for major spill occurrences. Cleanup of all but the largest spills would not be feasible. Direct impacts to water quality would be minimized since the concentrates would be relatively insoluble and background seawater concentrations would be likely to be well below normally accepted aquatic life standards.

The most prevalent summer wind conditions, from the west or northwest, would tend to move spills down the coast toward Cape Krusenstern. For large oil spills, this movement could increase the extent of impact such that a spill could have greater than local significance. For chemical or dispersible spills, the transport would tend to disperse the material rapidly.

The risk of spillage would be directly dependent upon the number of transfers, the number of transfers between unstable platforms and the number of ships involved (Table V-15).

The SPCC Plan (Appendix 2) required by EPA would also be certified by the state. The plan would outline rapid spill reaction measures, materials and equipment required for containment and cleanup procedures. Training programs and spill contingency staffing requirements would be outlined in detail.

Table V-15

TRANSFER AND SHIPPING FREQUENCY

	Alternatives	
	1 & 2	3
Number of Concentrate Ships/Year	13	13
Number of Concentrate Barges/Year	420	84
Number of Concentrate Transfers/Year	853	168
Number of Concentrate Transfers/Year at an Unstable Platform	0	84
Number of Material and Equipment Ships/Year	13	13

Note:
Transfer = movement from one ship to a dock or another ship on or over water.
Unstable Platform = a floating ship or barge subject sea conditions.

Source: Cominco Alaska, Inc.

Alternative 2

The marine water quality impacts of this alternative would be similar to those for Alternative 1.

Alternative 3

The marine water quality impacts of this alternative would be similar to those for Alternative 1 with the following exceptions:

- Oil would be stored onshore at the port site thus increasing the risk of onshore fuel spill contamination.

- Oil would be lightered instead of piped to shore. Lightering presents different spill risks and, since more connections to pipelines and more transfers would be made, oil spill risk would increase. Fuel transfer by lightering would be subject to wind and weather limitations as discussed below.

- Lightering ore concentrate to a moored ship would be subject to interruption due to adverse weather conditions. Transfers between the lighter and the ship, two unstable platforms, would not be possible when wave heights were over 1.5 m (5 ft). These conditions exist approximately 20 percent of the time during the 100-day shipping season. Delay of the ore concentrate vessels would cause substantial increased costs. In addition, these increased costs would force attempts to work in marginal weather conditions, greatly increasing the chance of significant spills of hazardous substances to the marine environment.

- Two tug-assisted 4,535 Mg (5,000 ton) barges would be used instead of one 907 Mg (1,000 ton) self-propelled barge. This would reduce the number of barge trips.

- According to shipping companies, neither clam shell loaders mounted on the bulk carrier or barge-mounted conveyors provide the necessary speed for open sea transfers. They also present more of a risk for equipment damage and spillage.

- Shipping frequency and number of transfers differ from Alternatives 1 and 2 as shown in Table V-15.

Approximately one-fifth the number of concentrate transfers would be made using Alternative 3. However, half of these transfers would be between two unstable platforms in the open sea (bulk carrier and lighter). Since concentrate transfers for Alternatives 1 and 2 would be all from or to a stable platform (dock or ballasted ship), and either under cover or by conveyor, the risk of spills for Alternative 3 would be considered slightly greater because of the following factors:

- Pressure of weather to speed transfers;

- Unstable open sea transfers; and,

- Transfer methods would be unproven and not desirable to shipping companies.

Air Quality

Alternative 1

Air pollutant emissions from the concentrate haul trucks' and supply trucks' exhaust would be negligible when averaged over nine to 12 trips per day and the 180 km (112 mi) round-trip distance. However, dust generation would be a serious concern. Measurements along the North Slope Haul Road from Atigun Pass to Prudhoe Bay have shown that dust accumulations exhibited a logarithmic distribution on both sides of the road, with greater accumulations downwind from the prevailing wind direction. Measured accumulations in one summer ranged from 50 to 100 g/m^2 at 30 m (98 ft) from the road, and from 2 to 3 g/m^2 at 1,000 m (3,280 ft) from the road (Brown and Berg, 1980). Dust accumulations were found toxic to many species of mosses and lichens with noticeable changes to vegetation alongside the road. Total accumulations during a 67-day period in summer were 28 to 56 Mg/km (50 to 100 tons/mi) of road.

Dust control measures could keep dust generation to low levels. These measures might include: road constructed of hard crushed rock; use of a subsurface fabric; water sprayed on dry days; use of chemical stabilizers and binders; use of wind screens and berms; and revegetation of road shoulder embankments and cuts and fills. Revegetation procedures would include mulching, fertilization and irrigation (if necessary due to drought). Rooted willow cuttings would be suitable for revegetation of wet slopes and stream crossing areas. Use of appropriate dust control measures would reduce potential impacts to roadside vegetation to insignificant levels. Dust control measures would be especially important to reduce impacts to vegetation in Cape Krusenstern National Monument.

Potential air pollutant sources at the port site facility include a small diesel power generator and ore concentrate unloading activity involving trucks and front-end loaders. Emissions from the power plant and loading equipment would be much lower than those discussed for the mine area, and would represent an insignificant percentage of National Ambient Air Quality Standards.

Dust control at the port site facility would include water sprays and chemical stabilizers. Revegetation would be attempted in areas not subject to vehicles. The ore concentrate would be unloaded in an enclosed area and stored under cover.

Offshore air pollution sources would include emissions from the lightering transfer operation and a small power generator on the ballasted ship. The emission plumes from either of these sources would not reach any nearby terrain in significant concentrations. The greatest potential source, the lighter, would be moving from ship to dock, which would disperse its emissions under even the most stagnant atmospheric conditions.

Alternative 2

Air quality impacts would be similar to those for Alternative 1, with the exception that there would be no concern about the effect of road dust plumes on Cape Krusenstern National Monument.

Alternative 3

Air quality impacts would be similar to those for Alternative 1. Slightly greater emissions from the lighter tugs would have no significant impact on air quality.

Visual Resources

Alternative 1

The southern corridor passes through Cape Krusenstern National Monument and would be visible in the middle and background view of travelers. Use level of the National Monument is presently extremely low; less than five visitors per year visit the site from outside the region. However, their concern for scenic qualities would be expected to be very high.

The southern corridor would be located in an area of moderate visual variety. Road construction would meet the visual subordinate criterion if surfacing material were selected which would not contrast with the natural landscape. Gravel borrow sites would be contoured and revegetated, while rock quarries would be made to resemble surrounding rock outcrops. Depressions resulting from borrow extraction would eventually fill with water to create small ponds and lakes along the corridor. If borrow material was extracted only from sites outside the Monument, the surface area and excavation depths of Sites 7 and 8 would increase. This would result in greater visual impact at those areas (Fig. II-8). Reclamation could permit road closure through the National Monument with subsequent natural revegetation of the road bed.

The proposed port site and transfer facilities would be located in partial retention Visual Quality Objective (VQO) areas. The proposed facilities could meet the VQO provided some design considerations were made.

As noted earlier for the mine area facilities, the port site facilities would be located on private land and the VRM Program as a management system is not applicable to private land. The discussion below, therefore, would be primarily of benefit to NANA as the landowner in its joint management of the project.

The port site would be the project component which would be most visible to those visitors with a major concern for visual quality. Located on the seacoast near Cape Krusenstern National Monument, the port site would be visible in the middle ground view of the majority of scenic viewers to the area. Since it is possible these facilities would be used well into the future, the port site and appurtenant facilities would require mitigating design measures to achieve the partial retention VQO. Port facilities which would complement the color, form, line and texture of the shoreline would be necessary and appropriate. If borrow extraction was not allowed within the boundaries of the Monument, the main concentrate storage building would be located at the port site rather than 4.0 km (2.5 mi) inland at Borrow Site 1 (Fig. II-16). The visual impact of this large structure would be substantial.

The offshore island tanker facility would be located approximately 1,097 to 1,216 m (3,600 to 4,000 ft) from the shoreline where highly scenic features occur. Because of its tremendous size, the visual impact would be substantial and visual quality considerations should be considered during facility design to achieve the partial retention VQO.

Alternative 2

All components of this alternative would occur in partial retention VQO zones except for two separate segments of the northern transportation corridor. Although scenic viewers would have a background view of the corridor, approximately 19 km (12 mi) of road corridor would cross retention VQO zones. This classification directs development activities to repeat the form, line, color and texture of the characteristic landscape. These sections of corridor would be considered more distinctive landscapes because they would traverse the highly scenic basins of the Kivalina and Wulik Rivers. Well planned design and reclamation techniques would be important to the maintenance of the retention VQO.

The port site location is considered highly scenic due to the distinct visual variety class of the coastline. The port site would require mitigating design measures to achieve the partial retention VQO. The visual impact of the offshore transfer facility would be similar to Alternative 1.

Alternative 3

This alternative would be similar to Alternative 1 except the lightering transfer system would not involve a ballasted tanker offshore. Visual impacts, therefore, would be substantially less than those for Alternative 1.

Sound

Alternative 1

During construction of the road, significant noise disturbance would occur from drilling and blasting activities at the borrow sites. If borrow material was extracted only from sites outside the Monument, there would be more noise generated during road construction than if borrow sites were spaced along the entire corridor. This would be due to borrow being hauled longer distances. During operation, the southern corridor road would be used consistently for nine to 12 round trips per day by concentrate truck/trailer units. Additional daily tanker and supply truck trips and one or two trips per day by light utility vehicles would occur. Use would be primarily during daylight hours with no traffic during periods of hazardous weather, such as fog or whiteout.

Sources of noise along the transportation corridor are shown below:

Concentrate truck/trailer units	90 dB(A) at 15 m (50 ft)
Tanker/supply trucks	90 dB(A) at 15 m (50 ft)
Utility/passenger vehicles	80 dB(A) at 15 m (50 ft)
Helicopter	82 dB(A) at 152 m (500 ft)
Helicopter	76 dB(A) at 305 m (1,000 ft)
Helicopter	70 dB(A) at 610 m (2,000 ft)

Maximum sound levels would be approximately 90 dB(A) at 15 m (50 ft). Sound levels from the road would be intrusive (to human conversation) under optimum propagation conditions (low temperature inversion) out to a distance of 0.8 km (0.5 mi), and noticeable above normal background sound levels of wind and rain to approximately 8 km (5 mi) from the road.

Assuming 12 round trips per day along the road corridor by concentrate truck/trailer units or tanker/supply vehicles (i.e., excluding other road vehicles, aircraft, etc.), at an average speed of 48 km/hr (30 m/hr), noise would be intrusive to humans at roadside under optimum propagation conditions approximately 3.3 percent of the time during a 24-hour period (or approximately 6.6 percent during a 12-hour "daytime" period). Under similar conditions, noise would be noticeable above normal background sound levels to humans at roadside somewhat less than 33 percent of the time during a 24-hour period (or somewhat less than 66 percent of the time during a 12-hour daytime period). At a distance of 4.8 km (3 mi) from the road, the percentages would be somewhat less than 27 and 53, respectively. Animals, which are generally more sensitive to noise than humans, would likely notice sound for a greater percentage of time at similar distances.

Helicopter and light plane flights from the mine area to the port site or to Kivalina should follow the road corridor or stay at elevations of 610 m (2,000 ft) or greater above ground level to the extent weather and destinations would allow. Helicopters and light planes should be required to detour around known raptor nest sites by 1.6 km (1 mi) or greater horizontally and vertically. No route deviation should be allowed to investigate wildlife, particularly muskoxen, caribou, grizzly bears, or nesting birds. Air transportation to and from Kotzebue should also follow a consistent route and maintain 610 m (2,000 ft) above ground level to the extent weather and destinations would allow. Failure to adhere to these restrictions could have significant local impacts on wildlife species; during caribou migrations the impacts could be significant on a greater than local basis.

Noise disturbance to visitors at Cape Krusenstern National Monument would be unavoidable within 8 km (5 mi) of the road corridor. The relative briefness of any potential exposure and the present infrequent visitation to this portion of the Monument would suggest that noise impacts due to traffic on the road would not be significant.

Potential noise sources at the port site and transfer facilities can be divided into those which propagate through the air and those through the water. Onshore air-propagated noise sources would include:

Concentrate truck/trailer units	90 dB(A) at 15 m (50 ft)
Tanker/supply trucks	90 dB(A) at 15 m (50 ft)
Diesel power generator	85 dB(A) at 15 m (50 ft)
Crane loader	70 to 85 dB(A) at 15 m (50 ft)

The combined sound level at 15 m (50 ft) would be approximately 93 dB(A) assuming all sources were operating simultaneously. During normal wave and wind conditions (generating 30 to 50 dB[A]), such a sound level would be discernible at a distance of approximately 1.6 to 3.2 km (1 to 2 mi). The relatively consistent nature of port facility sounds would be unlikely to cause terrestrial wildlife avoidance at distances greater than that also caused by sight and smell stimuli.

Offshore underwater noise sources are shown below:

	dB at 305 m (1,000 ft)
Transfer barge/lighter/tug	106
Shipboard generator	102
Ore ship transfer operations	92

Noise levels are given in dB instead of dB(A) since the characteristics of marine mammal hearing are different from those of humans. Most noise would be restricted to the June through mid-October period when the transfer facility would be operated. Ice-free conditions would likely exist from late June to early October. Summer natural underwater sound levels would range from 30 to 75 dB. Natural ambient sound levels underwater with moving ice present would range from 75 to 85 dB. In comparison, moderate to heavy shipping noises would range from 70 to 75 dB.

Background underwater noise sources would include ice action, waves, wind, rain and marine life. Potential sounds from the port and transfer facilities would be discernible above natural background sound levels for approximately 8 to 16 km (5 to 10 mi) underwater. They would be capable of masking sounds from some marine mammals, thus limiting the range over which these animals could detect members of their own and other species. Most sounds produced by port operations would be below 2,000 Hz with a greater proportion below 200 Hz. Seal communications are not disturbed by offshore operations sounds since most seals generate sounds in a fairly broad spectrum, up to 3,000 Hz. Belukha whales vocalize above 2,000 Hz. Noises generated by Gray and bowhead whales, however, are belches and moans, mostly below 500 Hz. This sound range would overlap those frequencies generated by offshore operations. Thus, communication among Gray and bowhead whales could be affected at least up to 16 km (10 mi) from the port site. The sounds might cause these whales to avoid the vicinity of the port site during summer operations. This avoidance would probably not be significant since bowhead whales would normally not be present at this time and Gray whales would be relatively infrequent visitors.

Alternative 2

Sound impacts would be similar to those for Alternative 1 with the following exception. The northern corridor would pass through areas more important to wildlife and subsistence users. Traffic noises would cause greater impacts on both.

Alternative 3

Sound impacts would be slightly less than those for Alternative 1. The offshore island facility would not exist, but sounds from the lighter operations would be similar in intensity to the ballasted ship operations.

Cultural Resources

Alternative 1

For those of the 13 archeological sites that could not reasonably be avoided by realignment of the southern corridor road, it would be proposed to the Advisory Council on Historic Preservation (ACHP), through the State Historic Preservation Officer (SHPO), that professionally designed recovery operations be conducted to preserve the site data and material that could not be preserved in place. On a site specific basis, measures to protect sites near the transportation corridor from indirect impacts would be proposed to the ACHP for approval.

The historical reindeer herding facility remains at the VABM 28 port site would be either directly or indirectly impacted depending on the specific port facilities location. Priority consideration would be given to a design to avoid the site, and to provide protection from indirect impacts. If avoidance were not a reasonable option, recovery and recording operations would be developed in consultation with the SHPO and the ACHP.

Because of ice scouring and littoral transport along the coastline, it is not likely that submerged archeological sites or historical shipwrecks would be encountered by construction of the offshore island transfer facility.

Management decisions relating to sites within Cape Krusenstern National Monument would be based on federal regulations, and on the additional consideration of their relationship to the prehistorical data base of the Monument.

If all these measures were taken, impacts would not be significant.

Alternative 2

For those of the 23 archeological sites that are determined eligible for the National Register and that could not reasonably be avoided by realignment of the northern corridor road, the same mitigation measures would be used as described for Alternative 1. This would also apply to the cabin at the Tugak Lagoon port site. As at the VABM 28 port site, it is not likely that archeological sites or historical shipwrecks would be encountered by construction of the offshore island facility. If all these measures were taken, impacts would not be significant.

Alternative 3

Cultural resource impacts would be similar to those for Alternative 1.

Subsistence

Alternative 1

The southern road corridor would be shorter than the northern corridor and would tend to parallel the natural topographic and drainage features of the region. As a result, it would traverse more upland habitat and have fewer stream crossings than the northern corridor. The upland and freshwater habitats along the southern corridor also tend to be less accessible and lower in quality and productivity and thus of less established value to subsistence hunters.

The western Arctic caribou herd is the primary subsistence resource along the southern corridor. The flanks of the Mulgrave Hills between Kivalina and Noatak provide good winter range. The southern corridor follows along a natural buffer zone between the primary winter caribou range in the Kivalina and Wulik River drainages and the secondary winter range on the wind-swept western slopes of the Mulgrave Hills. If the road were to grossly impede customary movements between these ranges, there would be immediate adverse impact on the Noatak subsistence harvest of caribou and perhaps on the long-term herd size.

The NANA/Cominco agreement would permit NANA to curtail road use during caribou migration periods when traffic might interfere with the normal passage of caribou through the vicinity. This option, if exercised properly, could mitigate many of the adverse impacts of road activity on caribou movements near the road corridor.

The southern corridor would cross about 187 streams, including tributaries of the Wulik and Omikviorok Rivers and New Heart Creek. Eleven of these stream crossing sites contain resident fish populations or spawning grounds. These sites are relatively remote from Noatak and Kivalina and are not routinely used for subsistence. However, degradation of spawning habitat or new fishing pressure as a result of increased access might impair downstream subsistence fisheries.

While the southern route passes near and through some habitat supporting moose and furbearers, habitat impacts would probably be local and minor, with minimal impacts on subsistence. Near the coast the corridor would enter wetlands and lagoon areas that support waterfowl populations, so there would be some local habitat loss and displacement of waterfowl.

The VABM 28 port site falls within a marine mammal harvest area. According to a 1974 survey by Mauneluk (Maniilaq) Association, marine mammals were the single most important subsistence food resource for Kivalina residents. Seals and ugruk (bearded seal) were most important, followed by walrus, and belukha and bowhead whales.

Marine mammal hunting is generally confined to the winter and spring months when the port would be ice-bound, so ship traffic from the port should not significantly disrupt harvest activities. However, port construction and year-round activities aboard the offshore transfer facility would likely displace some marine mammals from the immediate area, resulting in a reduction in size of the local marine mammal harvest area. Any mishaps such as episodic or chronic spillage of fuels or chemicals that could seriously damage habitat quality might adversely affect marine mammal populations. However, the net impact of ordinary port operations on marine mammal resource availability would not be significant.

Alternative 2

The northern corridor would traverse an area important to caribou as primary winter range and for migration. This area is intensively used by Kivalina hunters. As noted in the assessment of impacts on terrestrial wildlife, disturbances from construction and traffic along the road corridor would likely result in reduced use of this habitat by caribou. There would be an unknown risk that road-related disturbances could cause an unfavorable shift in winter grazing habits or deflect traditional caribou migration routes so that subsistence access to this important food resource would be reduced.

The upper reaches of the Wulik and Kivalina Rivers support moose populations that are harvested by Kivalina residents, but moose generally adapt more easily to human intrusions. Finally, where the road corridor would cross the Ikalukrok, Wulik, Kivalina and Asikpak drainages, it would pass through habitats of small furbearers important to Kivalina trappers. However, the impact on these species would likely be local and minor.

The northern corridor would make numerous crossings of the main streams and tributaries of the Kivalina, Wulik and Asikpak drainages. The crossing areas would impact fish spawning areas and other productive habitat. Kivalina residents depend heavily on downstream sections of the Wulik and Kivalina Rivers for their fall subsistence harvest of Arctic char. Road construction and use have the potential to impair both local habitat and important downstream subsistence fisheries if water quality were degraded or fish passage interrupted.

Lagoons and wetlands along the coast provide habitat for waterfowl. Construction and use of road and port facilities near Tugak Lagoon could possibly result in reduction of waterfowl habitat of minor importance to subsistence hunters.

The area offshore from the Tugak Lagoon port site is used by Kivalina residents for harvest of marine mammals like the VABM 28 port site. The relative level of subsistence hunting effort offshore from Tuguk Lagoon reportedly has shifted southeastward in recent years. Braund and Associates (1983) found that the area from Kivalina south to Rabbit Creek is now most intensively used for marine mammal harvest. An earlier study (Saario and Kessel, 1966) reported marine mammal hunting was most intensive north of Kivalina to Cape Seppings. This may be a dynamic phenomenon which periodically undergoes change. In general, it appears that the local impacts of the Tugak Lagoon port site and transfer facility on subsistence would be similar to the impacts noted for the VABM 28 site in Alternative 1.

Alternative 3

Subsistence impacts for this alternative would be similar to those for Alternative 1, except that the absence of the ballasted ship should lessen the potential for disturbance of marine mammals during the spring subsistence hunting period. This would not represent a substantial difference.

Recreation

Alternative 1

Recreational hunting, trapping and fishing activities by Cominco employees would be prohibited during their active phase of work or residence at project locations, or while moving to or from their residences and work sites on Cominco transportation. The southern road corridor would cross areas used by migrating fish and game species. The route would be public in that it would be available for use by other future resource developments in the region, but it would not be open for general public use. Current recreational use of Cape Krusenstern National Monument is extremely low due to difficult access and overland travel.

Development and human use of the port facility could also lead to a potential increase in recreational activity near the coast. Similarly to the road, the port and transfer facilities would be for industrial resource use. However, if eventually they were made available for public use, access would be improved for non-residents, and hunting, fishing, sightseeing and coastal boating might increase. Good waterfowl habitat would be more accessible and these species would probably receive greater exploitation.

Project facilities would replace a roadless and generally undeveloped recreational experience with a developed setting. However, the impacts on existing recreational activities would be minimal. In fact, recreational use of the project area might increase due to more people residing in the area; better access and support facilities; more publicity; and establishment of an industry for which Alaska is known worldwide. Some people might be discouraged from using the area as its wilderness character would decrease, but more might be encouraged to engage in local recreational activities as cultural development increased.

Alternative 2

Impacts from development of this alternative would be generally similar to those from Alternative 1. However, the northern road corridor would intersect more important moose, caribou and fish habitat, and would thus have a greater potential for increasing hunting and fishing activities. In particular, major fish streams of the area would be crossed at several locations, and increased recreational fishing activities would adversely impact important fishery resources in those streams. If angling and associated disturbance occurred during the late summer char spawning period, char populations could be severely impacted in the Kivalina drainage.

Alternative 3

Recreational impacts would be similar to those for Alternative 1.

Regional Use

Analysis of regional use impacts must be made in light of the stated positions of the landowners in the project area regarding use of the transportation system right-of-way and port site.

The State of Alaska, through its Department of Natural Resources, has stated that it will authorize development of a single industrial use transportation corridor to connect mineral deposits in the Western De Long Mountains with tidewater. The route would be public in that it would be available for use by other future resource developments in the region (but not to the general public). As a public industrial use route, reciprocal right-of-way agreements would be required whenever individual, corporate or other private ownership was encountered to ensure public access across these private lands. Likewise, tideland and associated upland port development would also be available to other users such as oil, gas, coal and other hardrock mineral exploration, development or support services (Wunnicke, 1983).

The National Park Service has also stated that if a Title XI right-of-way was issued across Cape Krusenstern National Monument, it would be for industrial resource use only and not open to the general public.

NANA Regional Corporation, as owner of the private land at the proposed VABM 28 port site, and probable owner of the land at the proposed Tugak Lagoon port site, has stated that it would make available a reasonable amount of land for other resource users at either port site at fair market value.

Also, while use of the road by other industrial resource users would be permitted, such users would be expected to reimburse the Red Dog project, or other appropriate entity, reasonable costs for building and maintaining the road.

Thus, from the perspective of access to the transportation corridor and port site, any of the three alternatives would provide a guarantee of reasonable access and use by other industrial resource users, and such reasonable access and use are considered assured for the following impact analysis.

Alternative 1

This alternative would provide a relatively flexible transportation system between the coast and the foothills of the De Long Mountains. The port site location would have adequate soils and be large enough to handle major expansion, if needed. Also, since the 122 m (400 ft) causeway would exist in all three alternatives, the presence of the ballasted tanker would add extra flexibility for transshipment of materials or supplies into or out of the region.

Alternative 2

The effects of this alternative would be similar to those for Alternative 1. At this early stage of development of the De Long Mountains area of Alaska, the differences between this alternative and Alternative 1 cannot be accurately assessed with respect to the geographic ability of the port sites and road corridors to serve other users. GCO's Lik prospect would be more easily accessible from the northern corridor, but would also be reasonably accessible from the southern corridor. From the standpoint of access to the port and road corridor by residents of Kivalina, the three alternatives would be approximately equally distant from the village.

Alternative 3

The regional use impacts of this alternative would be similar to those for Alternative 1 except that the absence of the offshore island would somewhat limit the flexibility of the port facility in serving other users.

Technical Feasibility

Alternative 1

Since all the options used to develop the alternatives were technically feasible, in determining the potential technical impacts of the alternatives, emphasis was placed on the technical complexity of the options.

The southern corridor road would have one major multi-span bridge over 30.5 m (100 ft) in length, and would have four minor single span bridges under 30.5 m. The road would be built through soil, slope, elevation and river bottom conditions that would be classified as moderately difficult or difficult to construct for 19 percent of its length.

The VABM 28 port site location would have suitable soils and bedrock at a depth of approximately 16.8 m (55 ft).

The offshore island transfer facility would use a technically complex system involving a self-propelled lighter and three concentrate transfers using conveyors. It would also employ a buried fuel pipeline that would be subject to ice-scour problems during the winter.

Alternative 2

The northern corridor road would have six major multi-span bridges (over 30.5 m [100 ft] in length) and would have six minor single span bridges under 30.5 m long. The road would be built through soil, slope, elevation and river bottom conditions that would be classified as moderately difficult or difficult to construct for 41 percent of its length.

The Tugak Lagoon port site location would likely have suitable soils, but the depth to bedrock is not known.

The technical impacts of the offshore island transfer facility would be the same as those for Alternative 1.

Alternative 3

The technical impacts of this alternative would be the same as those for Alternative 1 except for the transfer facility. This alternative would employ a technically complex lightering system using two larger lighter barges towed by two tugboats. Concentrate transfers to the bulk carriers would be by clam shovels between two unstable platforms. This facility would not have a buried pipeline subject to ice-scour problems during the winter, but would have to lighter fuel ashore from ocean-going ships.

Cost

Capital and operating costs can be calculated for eight of the project components: the mine, tailings pond, mill, worker housing, water supply, power generation, transportation system and port facility. All components, except the transportation system and the port facility, are common to all three alternatives and would, thus, cost approximately the same regardless of which alternative were selected. Any significant differences in cost among alternatives, therefore, would result from the transportation corridor location and the type of port facility selected. Table V-16 presents the estimated road system and port facility capital and annual operating costs for each of the three alternatives.

NO ACTION ALTERNATIVE

The No Action Alternative is identical to the base case forecasts for economic and population growth and regional change.

Generally, the base case forecasts for the near future anticipate a slowing population growth and a static or deteriorating regional economy. Over the past decade, growing federal and state expenditures have accounted for the major share of the region's cash economic expansion. Paralleling this trend has been a marked shift toward local control over the administration of public resources. Now, curtailed federal expenditures and shrinking state revenues and expenditures make it unlikely that the economic expansion of recent years would persist. Since local government and other local public service agencies are heavily dependent on federal and state funds, their ability to improve or sustain current levels of community services might be impaired. Even so, in the absence of private economic development, the public sector would likely continue to dominate the region's economy.

The potential impact of the No Action Alternative on the cultural and social evolution of the region is not clear. To the degree that the project is seen to favor modernization and a departure from established cultural values, the No Action Alternative would forego those social changes. However, it is

Table V-16

ESTIMATED ROAD SYSTEM AND PORT FACILITY CAPITAL[1] AND ANNUAL OPERATING COSTS ($000) FOR EACH ALTERNATIVE

	ALTERNATIVE 1		ALTERNATIVE 2		ALTERNATIVE 3	
	Southern Corridor VABM 28 Port Site Offshore Island Fac		Northern Corridor Tugak Lagoon P. S. Offshore Island Fac		Southern Corridor VABM 28 Port Site Lightering Facility	
Component	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost
Road System	74,700	2,614	125,700	3,334	74,700	2,614
Port Facility	54,700	1,605	54,700	1,605	74,000	2,966
TOTAL COST	$129,400	$4,219	$180,400	$4,939	$148,700	$5,580

Source: Cominco Alaska, Inc.

[1] Based on July 1983 capital costs.

plausible that if public sector growth flagged, the No Action Alternative could mean a halt in the shift of political and social power to resident institutions. This, in turn, might tend to stall the movement now underway to restore traditional Native cultural and social values.

The Red Dog Mine property represents a major economic asset of the NANA Regional Corporation, which is the most important non-governmental economic and political institution in the region. The No Action Alternative, which would mean no development of this asset, might adversely affect the long-term viability of the NANA Regional Corporation.

MITIGATION

The term "mitigation" can have several meanings in an EIS process. These include:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

In this EIS, no significant impacts were found that would require, or would be capable of being mitigated by, compensation as defined in (e) above. Mitigation by avoiding impacts altogether, as in (a) above, was incorporated extensively throughout the EIS process through elimination or alteration of options or designs to avoid significant effects (Chapter III). The other three forms of mitigation, i.e., minimizing impacts, rectifying impacts through repair, and eliminating impacts over time (as in [b], [c] and [d] above), are the forms of mitigation generally grouped in this EIS under the term "mitigation" and are referred to as "mitigative measures" in the text.

Without these numerous mitigative measures, or environmental safeguards, which have been incorporated in the Red Dog project plans for design, construction and operation, there could be many significant impacts. In the following paragraphs, these mitigation measures are briefly described to pull together in one place the major environmental safeguards that would be used in project development. Details of these mitigative measures are discussed under individual discipline environmental consequences earlier in this chapter.

Vegetation and Wetlands

Vegetation would be restored in disturbed areas not subject to vehicle use or scheduled for future disturbance to the extent feasible under Arctic conditions.

Terrestrial Wildlife

Aircraft and helicopter operators would be provided maps and required to travel corridors and at altitudes which would avoid known raptor nesting sites and wildlife concentrations to the extent weather and destinations would allow. Harassment would be prohibited. Flight areas would be updated as required to avoid caribou movements. Vehicle use of the road would be restricted or eliminated when caribou movements occurred near the road. Workers would not be permitted to hunt or trap during the active phase of their work and residence at project locations, or while moving to or from their residences and work sites on Cominco transportation.

All garbage collection sites and incinerators would be fenced using adequate "bear-proof" fencing, and workers involved with garbage disposal would be instructed in proper collection, handling, and incineration techniques. Incinerator wastes and unburnable solid wastes would be buried in the tailings pond to eliminate landfills and their associated wildlife attraction problems.

Feeding of animals would be prohibited and this would be strictly enforced. The ADF&G regulation prohibiting such feeding (5 AAC 81.218) would be posted conspicuously throughout the camp. All workers would receive environmental training which would stress the importance of this prohibition, the usual consequences to the animals themselves from being fed, and the potential danger to employees (e.g., bear/human contacts, rabid foxes).

Groundwater Resources

Runoff from the ore body would be collected by a diversion ditch and routed to the tailings pond. If seepage occurred from the tailings dam foundation it would be collected and pumped back to the tailings pond.

Freshwater Resources

Hydrology and Water Quality

The ore body diversion ditch would collect surface runoff and sediment and route it to the sump sedimentation pond and tailings pond. All mill and domestic wastewater would also be routed to the pond. Mine, mill and domestic wastewater in the tailings pond would be treated to meet appropriate permit standards before being discharged. The pond would be sized to handle the 10-year recurrence 24-hour flood event. Spillage control plans and rapid response to spills would be the primary mitigative measure for spill impacts. Appendix 2 (SPCC Plan) outlines the proposed draft plan for spill reaction.

Guidelines for road construction in the Arctic would be followed to prevent sedimentation impacts. The most important guidelines would include: use of erosion control measures which prevent restriction of cross-drainage; avoidance of icings and ice-rich soils; and use of stream crossing designs which minimize bank erosion and channel scour. Development of specific construction schedules should include consideration of: ground conditions most suitable for construction (e.g., frozen); raptor breeding, incubation and hatching periods; caribou wintering areas and major movement timing; fish presence at stream crossings; and marine mammal migrations and subsistence hunting periods.

Biology

Mitigation measures which protect water quality would also protect aquatic plant, invertebrate and fish resources.

Air Quality

Permit requirements would ensure control of gaseous and particulate emissions from mill operations and power generation. Dust suppression measures such as watering and chemical treatments would be used for mine access roads, the open pit, overburden storage piles and the road to the port site.

Sound

Offshore port site noise would be minimized during the March through June period when it might affect subsistence seal hunting and whale migrations. Helicopter and fixed-wing operations would be restricted to the road corridor or to altitudes above 610 m (2,000 ft) outside the corridor to the extent weather and destinations would allow.

Cultural Resources

The preferred course of action would be to avoid all prehistorical and historical sites. Based on a plan of mitigation developed in cooperation with the SHPO and approved by the ACHP, data recovery operations would be conducted at those sites that could not be avoided, or which were discovered during construction.

Subsistence

Hunting and fishing activities would be restricted for project personnel in order to protect traditional Native subsistence activities. Road activity would be restricted or eliminated during periods of major caribou movements or at other times when such activities might threaten or interfere with subsistence resources or harvests.

Socioeconomics

Cooperation with NANA and local community officials in Kotzebue and the villages would ensure that mitigative measures were applied to problems which developed.

MONITORING

Monitoring programs are usually established in response to permit requirements. However, additional monitoring requirements have been suggested here to answer environmental concerns since: (1) the baseline data collection period of two years, while adequate for EIS writing purposes, may have been insufficient to document the full range of natural fluctuations (e.g., in caribou migration routes and timing; runoff and water quality); and, (2) some potential environmental impacts associated with project operations were difficult to accurately predict in advance and can only be understood after actual experience.

Vegetation and Wetlands

Dust from gravel roads can be detrimental to nearby vegetation. Road corridor vegetation would be examined at five-year intervals to ascertain if dust generation from the road were excessive and/or damaging vegetation communities.

Terrestrial Wildlife

It is not possible to predict the influence of the road corridor and associated activity on caribou movements and timing. Before and during the first few years of project operation, caribou movements would be monitored to determine both a baseline and then the extent of avoidance and alteration of traditional movement patterns due to road activities.

Groundwater Resources

Seepage through the dam foundation might occur if the foundation thawed. Seepage rates and water quality measurements would be made annually at mid-summer to determine seepage trends with time.

Freshwater Resources

Hydrology and Water Quality

DEC and NPDES permit requirements would be expected to specify a water quality monitoring program at the confluence of Red Dog and Ikalukrok Creeks. Sedimentation ponds at the ore zone diversion ditch sump, the tailings dam seepage collection facility and the port site would be checked on an annual basis and excess sediment accumulations removed. An ongoing maintenance program along the road corridor and access roads would check for: (1) excess icings in stream crossing structures; (2) excess bank erosion or scour at stream crossings; (3) excess icings along the road embankments showing evidence of interference with cross-drainage; (4) excess settlement and erosion of fine soil ice-rich subgrades; and (5) excess erosion or slumping of cuts, ditches and culvert outfalls. Potential problems should be corrected before environmental impacts to water quality or fish passage could occur.

Physical and Chemical Oceanography

Predictions in this document on nearshore sediment transport would be checked after several years of operations. Qualitative assessments would be made of the extent of sediment scour and deposition near the dock, and ballasted ship (if selected).

Marine Water Quality

In order to determine any cumulative influence of small spills on the marine environment, bottom sediment sampling would be done at five-year intervals. Transects parallel to the beach near the dock and offshore would collect bottom samples and analyze for concentrations of zinc, lead, cadmium and petroleum hydrocarbons.

Air Quality

Records would be kept of typical plume behavior for the power generator and driers to avoid any possibility of air quality degradation at the worker accommodations. A notice would be posted at the accommodations for workers to report any episodes of objectional odors and gases reaching the area from the mill. Permits would require periodic monitoring of emissions from the mill operations.

Cultural Resources

The Cultural Resources Management Program would be periodically checked to verify compliance with the ACHP Memorandum of Agreement stipulations.

Subsistence

Monitoring of project influence on subsistence hunting would be in response to NANA concerns as raised by the Red Dog Project Subsistence Committee presently organized to identify and minimize potential subsistence problems.

Socioeconomics

Continued coordination with NANA and local community officials in Kotzebue and the villages would identify project related social, cultural and economic problems as they might develop.

Recreation

Monitoring of potential problems associated with increased recreation would be in response to NANA and National Park Service concerns.

RECLAMATION PLAN

Under existing law there are no specific requirements for reclamation other than those desired by the landowner. This section presents a summary of a conceptual plan developed by Cominco Alaska for NANA for the protection and reclamation of land and water resources potentially affected by various components of the Red Dog project. The conceptual Reclamation Plan may be found in Appendix 1.

Open Pit Mine

The area of land disturbed by the open pit mine and access roads would ultimately reach approximately 134 ha (330 ac). Soils in this area are shallow, stony and contain toxic levels of zinc, lead, copper and iron. There appears to be little potential for stockpiling soil for later use. Reclamation of the open pit would have unusual problems due to the proximity of the ore body to Red Dog Creek and the steep, rocky sides of the pit. Backfilling the pit, resloping pit walls to natural contours and restoring the original course of Red Dog Creek would probably not be practical under existing Arctic conditions. Upon completion of mining, Red Dog Creek would be diverted back into the pit, creating a lake with a water level at the 274 m

(900 ft) elevation. The surface area of the lake would be approximately 40 ha (100 ac) with maximum depths to approximately 122 m (400 ft).

Water quality of the lake would be dependent on the extent of contact with residual ore materials. The volume of the lake would be approximately five times the annual mean inflow of Red Dog Creek at this point. This means that the water quality of the lake discharge would show lower seasonal fluctuations compared to pre-mining conditions. Because of the existing degraded water quality of Red Dog Creek, mean water quality of the lake discharge might substantially improve over present natural conditions. All of the ore with high concentrations of lead and zinc would be removed, leaving only low grade material in contact with the lake water. The depth of the lake would restrict oxygen contact with remaining mineralized rock, reducing dissolution and release of toxic metals. The lake surface would be frozen over from October through May, further restricting circulation of oxygen-rich water to mineralized areas. In summer the lake would stratify with warmer water overlying cold water, which would also restrict lake circulation. As a result, a substantial improvement in the water quality of Red Dog Creek might be expected.

Overburden Storage

Mineralized and unmineralized overburden rock not suitable for mill processing would be stockpiled on the east side of the tailings pond. The surface area of this storage site would be approximately 101 ha (250 ac). Vegetation types present in the area include dwarf shrub tundra and low shrub tundra. Underlying a shallow organic layer is approximately 1 m (3.3 ft) of annually thawed silty soil material. This material would be removed where necessary.

Overburden storage areas would be constructed by dumping and spreading methods designed to increase overburden stability, accelerate freezing of the overburden and prevent leaching. To restrict significant leaching of toxic materials, the surface of the sites would be compacted and covered with a frozen layer or other impervious material to prevent infiltration of rain or snowmelt. Overburden storage areas would be recontoured as required to achieve permanent slope stability and facilitate revegetation and restoration to natural appearance. Soil cover and vegetation would be placed over the impervious surface layer of the dumps. Particular care would be taken to control runoff from waste piles of oxidized overburden and low grade mineralized ore. If it proved infeasible to completely restrict runoff from mineralized overburden piles, they would be moved to the tailings pond and placed in a layer over the tailings.

Tailings Pond

The area of land disturbance associated with the tailings pond would be approximately 237 ha (585 ac). The reclamation plan for this project component would include removal and stockpiling of surface organic materials and soils for future use if feasible under Arctic climatic constraints. The pond would impact an area currently covered with dwarf and low shrub tundra and sedge-grass tundra along the streams. Soils of the drier tundra areas are similar to those described in the waste dump area. The wetter sedge-grass tundra soils are organic with an active depth of approximately

0.6 m (2 ft). When mining operations ceased, free standing water in the tailings pond would be treated and discharged to Red Dog Creek. After the then-exposed tailings froze, lined channels for runoff would be constructed across the tailings to stabilized spillways in the dam. Coolant pipes might be installed in order to enhance freezing of the tailings to permit access of equipment.

The surface of the pond area would be restored to an appearance resembling that of the surrounding terrain. Application of lime might be required to neutralize the potential acid generating surface of the tailings. The depth of material spread over the tailings to support vegetation would be sufficient to prevent thawing of the tailings when the active layer reached maximum depth of 0.5 to 1.0 m (1.6 to 3.3 ft) in late summer. If feasible under Arctic climatic constraints, stockpiled surface and organic material would be used. Revegetation, reseeding, mulching, fertilizing and irrigation would be done as needed to restore a tundra-like appearance to the reclaimed pond.

Mill Site, Worker Housing, Airstrip and Access Roads

The area of land disturbance associated with these facilities would be approximately 38 ha (95 ac) of sedge-grass tundra, dwarf shrub tundra and open low shrubland. At completion of the operating life of the mine, the facilities would be removed and the sites rehabilitated. All equipment, buildings and other surface structures would be dismantled and removed from the site. Where remaining concrete foundations would be significant obstacles to regrading, they would be removed to ground level. The airstrip, service areas and access roads would be scarified to relieve compaction, and recontoured, if necessary, to restore natural drainage. Culverts and bridges would be removed and open drainage channels would be restored. Water bars would be constructed to control erosion. Suitable vegetation would be established on disturbed sites by applying revegetation techniques developed during the operating life of the project.

Bons Creek Water Supply Reservoir

The area of land disturbance associated with the reservoir would be approximately 31 ha (76 ac) of dwarf shrub tundra. Reclamation of the water reservoir would involve either breaching the dam structure, or allowing the lake to remain with a permanent spillway. An evaluation of regulatory agency desires at the time of mine closure would be required to determine the most satisfactory action for reclamation.

Transportation Corridors

The area of land disturbance associated with the southern corridor would be about 197 ha (487 ac). The area disturbed along the northern corridor would be about 257 ha (634 ac). It is possible that the road corridor would be used for other regional purposes beyond the operating life of the mine, and reclamation would not be required. If reclamation were required, all bridges and stream crossing structures would be removed and drainage courses restored. The road surface would be scarified to relieve compaction and, where necessary, recontoured to restore a natural appearance. Water bars would be constructed to control erosion. Native plant species would be established on disturbed areas using revegetation techniques developed during the operation period of the project.

Borrow pits would be reclaimed when no longer needed for maintenance purposes. Where practical, slopes would be recontoured to an appearance compatible with the surrounding terrain and revegetated using appropriate Arctic techniques. The side slopes of rock quarries would be made to resemble surrounding rock outcrops. Depressions resulting from gravel and rock extraction would be allowed to fill with water to form ponds or lakes.

Port Site

The area of land disturbance associated with the port site would be approximately 20 ha (50 ac). It is possible that the port site would be used for other regional purposes beyond the operating life of the mine and reclamation would not be required. In the event the facility were abandoned, all buildings, equipment and other surface structures would be dismantled and removed from the site. Concrete foundations would be removed, if necessary, to allow site recontouring. Crushed rock pads would be scarified to relieve compaction and perimeter slopes would be recontoured. Shoreline features would be restored following removal of the dock. Natural shore transport processes would restore the original beach slopes and profiles within a few years. Native plants would be established on disturbed areas. The ballasted ship transfer facility would be refloated and removed.

Reclamation Research

During the operating period of the project, revegetation techniques would be assessed and refined on sites representative of the major kinds of land disturbance. Techniques investigated would depend on the nature and severity of factors identified as limiting to plant growth on the various waste materials. Development of practical methods for conserving surficial soil and organic material for use in reclamation of waste rock, tailings and borrow pits might also be necessary.

OTHER PROJECT IMPACTS

The Red Dog project as a whole would have impacts irrespective of which specific alternative were ultimately implemented. Several of these are discussed below.

Regional Impacts

The NANA region, together with the western quarter of the North Slope Borough and the federal outer continental shelf off the western Arctic coast, is thought to be endowed with substantial energy and other mineral resources. Development of the Red Dog mine would be the most advanced effort to date to develop a major resource deposit in the region. The other natural resources of outstanding interest in the larger region are oil and gas, hardrock minerals and coal. The presence of some of these other resources is well established and some are as yet of only speculative interest. In every case, their feasible development for export awaits either better definition of resource values through further exploration, more favorable commodity market conditions or provision of transportation and other development infrastructure.

While development of these other economic resources is not imminent, it is possible that their future development feasibility might depend on shared use of transportation sites, corridors or other infrastructure (particularly the surface transportation route and port site) established for development of the Red Dog mine. Since both the road and port site would be available to other industrial resource users and support services, the most important resource prospects are reviewed below.

Oil and Gas Resources

Alaska's western Arctic is generally suspected to possess substantial oil and gas resources. The areas of highest interest are outside but close to the project area. To date, there has been spotty, fruitless exploration for oil and gas in the Kotzebue Sound upland perimeter, and north and east of the study area. Now, within the next five years, a series of major federal and state oil and gas lease sales are scheduled.

The federal Department of the Interior has two offshore lease sales pending for the outer continental shelf waters of the Chukchi Sea north and west of the project area. These are: the Barrow Arch Sale #85 (February 1985); and the Barrow Arch Sale #109 (February 1987). The State of Alaska has two lease sales scheduled for the region: the Hope Basin Sale #45 (September 1985) in the vicinity of Kotzebue Sound; and the Icy Cape Sale #53 (September 1987) north of the NANA region. There are also some existing leases and more proposed in the western quarter of National Petroleum Reserve in Alaska. Finally, the NANA Regional Corporation and the Arctic Slope Regional Corporation each have landholdings with petroleum potential in northwestern Alaska. Both have sponsored limited exploration programs in the northwestern Arctic, without commercial success to date.

It would certainly be premature at this stage to settle on whether, where or in what volume oil or gas reserves might be discovered in the region. Still, some general features for a feasible transportation system for oil export (at present, natural gas finds do not appear likely to be commercially valuable) would be fairly well fixed in advance by certain economic, technical, geographic and environmental conditions. Due to the remote, frontier status of the region and its lack of transportation and other economic infrastructure, the threshold for pioneer commercial discovery would be extremely high, especially for the Chukchi Sea offshore province. A recent economic analysis (Dames & Moore, 1982b) estimated that the minimum economic field size would be about 1.5 billion barrels of recoverable oil. The minimum economic size for an upland oil field would be smaller, but still must be large enough to absorb the cost of an overland pipeline spur eastward to the Trans Alaska Oil Pipeline or westward to a tidewater port, plus the cost of a marine terminal if none existed.

Assuming that offshore or upland commerical reserves would eventually be discovered in the western Arctic, it would be most likely that the specific configuration and siting of offshore, surface, pipeline or port facilities for development and transport of crude oil would be dictated by considerations as yet unknown and independent of the status of the Red Dog project. First, geographic, technical, environmental and economic factors would strongly favor a choice of overland and/or marine facilities specifically designed for, and exclusively dedicated to, petroleum handling, without regard for transport facilities installed for the Red Dog mine. Second, the crude oil production threshold would be extremely high. It would entail a multi-billion dollar capital investment in production and transportation facilities that would dwarf the anticipated cost of the Red Dog project. For these reasons, there would be a relatively low probability that future decisions about petroleum facilities would be much influenced by the comparatively modest capital investment committed to the Red Dog mine.

Hardrock Minerals

The Western Brooks Range/De Long Mountains area is a highly mineralized region whose potential has not yet been fully explored. Apart from the Red Dog mine, the two hardrock mineral deposits that have so far been most seriously considered for large-scale commercial development are the copper-zinc-silver deposits in the Ambler District, approximately 275 km (172 mi) southeast of the Red Dog mine site, and GCO Minerals' Lik lead-zinc-silver deposit 19 km (12 mi) northwest of the Red Dog mine site.

The 1981 Western and Arctic Alaska Transportation Study (WAATS) examined 10 transportation systems, involving combinations of six corridors and four transport modes, for export of mineral production from the Ambler District. The shortest route to tidewater was an overland corridor for a road, rail or slurry pipeline system to the coast near Cape Krusenstern. This corridor traversed parts of Kobuk National Monument, Noatak National Preserve and Cape Krusenstern National Monument. Bear Creek Mining Company, a subsidiary of Kennecott Copper Company and holder of substantial reserves in the Ambler District, has stated its preference for this general route, terminating at a port site in the vicinity of Tasaychek Lagoon in Cape Krusenstern National Monument, about 38 km (24 mi) south-southeast of VABM 28 (Bear Creek Mining Company, 1983). Since this route from the Ambler District and the proposed Red Dog southern corridor converge on the coast at a right angle, a common overland corridor would not seem feasible. A common port site would require a coastal link or a rerouting of the final leg of the overland route from the Ambler District. Thus, apart from the potential for a common port site, presently proposed transportation corridors for the Ambler District do not seem likely to be affected by development of the Red Dog project.

On the other hand, the Lik deposit is similar in mineral content and infrastructure requirements to the Red Dog mine, as might be other deposits discovered in the immediate vicinity of the Red Dog mine. The economic feasibility and development plans for these as yet speculative prospects might be affected by the development scheme for the Red Dog mine, especially by the location, design and capacity of common-use transportation facilities, including the port site. For smaller mining operations, however, especially placer gold, construction of a road from the coast into the De Long Mountains could be an important stimulus.

Coal

The State's Division of Geological and Geophysical Survey (DGGS) estimates that the western Brooks Range north and east of the Red Dog project area holds Alaska's most massive coal deposits, perhaps a trillion tons of recoverable coal. However, the costs of surmounting the obstacles to production and transportation of these deposits under Arctic conditions place these deposits at a serious competitive disadvantage with other sources of supply. Therefore, development of these Arctic coal reserves does not appear likely in the foreseeable future. As with oil and gas development, geographic, technical, environmental and initial high capital investment factors associated with coal development would largely dictate the choice of overland and/or marine facilities specifically designed for coal production. There would be a relatively low probability that future decisions about coal development would be significantly influenced by the Red Dog project.

The Morgan Coal Company is in the initial stages of considering the development of a coal field 32 km (20 mi) east of Point Lay (180 km [112 mi] northeast of Cape Lisburne). The company has expressed some interest in using the proposed Red Dog port site. BLM will begin an EIS process in 1984 to review the major project components and determine the preferred option for coal shipment.

If construction of a road and port for the Red Dog project does promote development of other industrial resource projects in the region, their incremental impacts would raise the ultimate overall impacts from initial development of Red Dog. Dust and noise pollution from increased use of the road, and its extensions, could additionally impact vegetation, caribou and other wildlife, and recreational users. Likewise, increased use of the port facilities would likely result in additional vessel traffic with a higher possibility of spills and effects on marine mammals. Other developments would impact visual resources and wilderness values, and could cumulatively affect the existing subsistence uses and historical lifestyles of local residents.

Since selection of the preferred alternative for this project has taken into consideration the regional use perspective, and since the State has specifically stated that there will be only one transportation corridor between the De Long Mountains and the coast, overall regional impacts should be somewhat mitigated by prevention of a proliferation of other corridors and port sites for future developments.

Increased General Public Access

Although the road right-of-way permit would limit use to industrial resource users, there cannot be any guarantee that such a restriction would apply indefinitely. Therefore, one of the most significant long-term impacts of development of the Red Dog project could be its effect on "opening up" the De Long Mountains region of northwest Alaska to people by construction of a regional port and surface transportation system. This could take the form of increased access from outside the area as well as increased ease of access for moving around within the area.

While the ability of people from outside the area to initially access the port and road systems would be limited, in time other projects (e.g., new mines in the De Long Mountains or further energy developments on the North Slope) would increase the ease of access and use of these systems. If the port facility and road were ever opened for use by the general public, they would be increasingly used by hunters, fishermen, hikers, birdwatchers, sightseers, etc. The mere presence of these additional people could ultimately have substantial impacts on several resources. In particular, wildlife and fish populations would be affected by increased harvests, requiring additional financial commitments and management efforts by the Departments of Fish and Game and Public Safety. ADF&G in particular would need to substantially increase resource assessment and monitoring efforts to minimize impacts of project development on fish and wildlife. Additional management efforts would likely be required to identify and close areas to (or limit) hunting, trapping and fishing in the vicinity of Red Dog Valley, the transportation corridor and the port site. Disturbance of caribou could have regional impacts if it caused a shift in traditional wintering areas or migration routes.

The archeological sites in the area might be affected by unauthorized collection of artifacts from sites within walking or off-road vehicle distance of the transportation facilities. Traditional subsistence activities could be affected either by direct competition with, or disturbance during, subsistence harvests. The impacts upon the fish and wildlife resource base discussed above could also affect subsistence harvests.

Additional access by off-road vehicles (ORVs) could have severe impacts upon vegetation in heavily traveled areas, especially at shallow fords at stream crossings. Such use might cause erosion which could cause increased siltation in the area's streams. Depending upon the severity, this might impact fish spawning and ultimately the subsistence use of that resource. If the southern corridor road along the less vegetated Mulgrave Hills was chosen, ORV trails might cause substantial erosion at those altitudes. Harassment of wildlife could also become a problem, particularly during the winter. Even though only industrial resource users would be permitted to use the road initially, ORV use would be very difficult to control. Past history shows that regulation of ORVs by land managing agencies has been largely ineffective. The degree to which ORVs might impact the Monument would depend upon how successfully the NPS could regulate their use.

Just the development of the project itself would have a significant impact on the wilderness values of the area. While not specifically recognized by recent federal or state actions as being of wilderness quality, the area is de facto wilderness and project development would irrevocably change that. The increase in the number of people using the area due to the easier access would certainly put some additional developmental pressures on the area. Increased access to Cape Krusenstern National Monument by recreational users would also detract from the wilderness experience of all users.

Increased ease of access within the area could also have substantial impacts on resources and how they are used, including subsistence. In particular, establishment of a road could intensify local subsistence use of fish and wildlife resources along the transportation system. The prohibition of hunting and fishing by workers during their active work phase would significantly reduce the impacts. If, however, such restrictions were not applied, the continuous presence of the camp workforce might result in off-hour casual recreational activity concentrated near the mine and along the road corridor. The northern road corridor would give camp occupants ready access to upriver fish populations not previously harvested. Both routes would allow access to caribou and other species on their winter ranges. The ultimate impact of the mine workforce upon the subsistence resource base would thus depend heavily on the restrictions placed on firearms and recreational use of camp vehicles, and on recreational fishing, hunting and trapping by mineworkers.

If the roadway became a convenient and popular overland transportation route for resident subsistence hunters, it might tend to extend the range and redistribute the subsistence harvest effort. It is hard to foresee whether such an adaptation would, over the long run, have a positive, negative or neutral effect on the resource base. Possibly, it would merely amount to a more efficient use of subsistence effort over a larger range.

Thus, while careful design, construction and operation of the project might be able to limit impacts upon fish, wildlife, vegetation, archeological and other resources, the improved ease of access both into and within the area for the public, which would be very difficult to restrict, would have definite and perhaps substantial long-term effects.

Cape Krusenstern National Monument Impacts

The purposes for which Cape Krusenstern National Monument was created are listed in Chapter IV. The various environmental impacts which would affect the Monument would be largely the same as those for other portions of the project area. These impacts have been described earlier in this chapter. However, because a portion of the southern road corridor in Alternatives 1 and 3 would cross the Monument, and because of Title XI requirements if the southern corridor were selected, a brief summary of the environmental impacts on the Monument is presented below. More detailed descriptions of these impacts may be found earlier in this chapter under the specific discipline headings.

Vegetation and Wetlands

The southern road corridor would cross approximately 38 km (24 mi) of the Monument. Approximately 77 ha (190 ac) of vegetation would be destroyed by actual road construction. Generally, more productive wetlands, e.g., waterfowl habitat, would be avoided by this road corridor. Road dust could have effects on vegetation to a distance of approximately 300 m (984 ft) from the road. A vegetation survey after five years of operation would determine these impacts and could recommend additional dust control measures, if necessary.

Terrestrial Wildlife

Other than the insignificant local loss of habitat from construction of the road itself, the major terrestrial wildlife concern would be indirect habitat loss from disturbance and possible interference with caribou movements. A program during initial years of project operation to monitor caribou movements as a basis for implementing NANA's authority to close operation of the road during major caribou movements would mitigate this concern substantially.

Freshwater Resources

Within the Monument, the southern road corridor would have only one major bridge crossing the Omikviorok River, and 20 minor bridge or culvert crossings. The road construction and maintenance guidelines as described earlier in this chapter would largely protect against water quality degradation due to sediment.

As described earlier, the most serious potential impact to water quality would be due to spills of oil, concentrates or toxic chemicals. Use of spillage control plans (draft SPCC Plan outlined in Appendix 2) and rapid response to spills would significantly reduce the probability that a spill would reach a water course via surface or groundwater paths.

The protection of freshwater quality would also serve to protect the invertebrate and fish species and habitats in those streams.

Air Quality

Vehicle traffic on the road would be the only source of air pollutant emissions within the Monument. Pollutant concentrations from these vehicle emissions would not reach significant levels even under the worst atmospheric dispersal conditions since the number of vehicles using the road per day would be so low.

Visual Resources

The degree of visual impact of the road, port site and transfer facility would be dependent on the attitude of the viewers. While present visitor use to this portion of the Monument is very low, the road, port site and the transfer facility would be obvious to viewers from most parts of the western portion of the Monument. The layout and colors of the port facility could be made to conform with the partial retention objective to mitigate much of the visual impact. However, if the offshore island transfer facility were selected, the visual impact of the large ballasted tanker would be high, but not significant considering the purposes for which the Monument was established. Dust plumes from road traffic could prove to be the most visible manifestation of the road. Proper use of dust suppressants could substantially reduce that impact.

Sound

Sound produced by trucks using the road within the Monument would normally be discernible to the human ear up to five miles from the road. Helicopters and light aircraft following the road corridor, while considerably less frequent in number, would generate sound to greater distances. In addition to the impacts of these noises on recreational users within the Monument, they would likely cause some avoidance of the corridor by caribou, bears and muskoxen.

Cultural Resources

There are six archeological sites in the Monument that would be within 1.6 km (1 mi) of the southern corridor road. As presently aligned, the road would not directly impact any of these sites. Potential indirect impacts would be mitigated by protective measures approved by the ACHP. Provisions would be made for emergency recovery operations under ACHP guidelines at sites discovered during construction. Intensive preconstruction surveys would make the likelihood of such site discovery during construction unlikely. If these measures were adhered to, there would not be significant impacts.

Subsistence

The presence of the road would likely have a mixed impact upon traditional subsistence use in that portion of the Monument. Road disturbance noted above would likely cause some displacement of large mammals and could, at the extreme, affect major caribou movements that traditionally cross the corridor. While initially the road would not be used to any significant extent by persons from outside the region, use of the road by people from outside the area would eventually increase. If this increased ease of access caused substantial numbers of hunters and fishermen to use the area, competition for subsistence resources could occur.

The increased ease of movement within the area, however, might serve to increase success of subsistence users by providing easier and quicker access to subsistence resources.

Recreation

The road and port site would also likely have a mixed impact upon recreational use. If the general public was ever permitted use of the road, easier access would increase the use by photographers, birdwatchers, hikers, etc. However, visitors to the Monument desiring a more primitive or wilderness experience would tend to avoid that area of the Monument.

The de facto wilderness nature of the project area would be permanently altered, with the loss of wilderness characteristics such as solitude and the opportunity for primitive types of recreational experiences. Also, since the Secretary of the Interior is required by Section 1317 of ANILCA to conduct a wilderness suitability study of Cape Krusenstern National Monument by December 1985, issuance of a right-of-way permit might preclude a significant portion of the Monument from being included in that study.

Coastal Geologic Processes

While no project related facility actually within the Monument would affect the transport of sediments, the possibility of development of a port facility has raised questions concerning potential impact upon the historic beach ridges at Cape Krusenstern. As discussed in greater detail earlier in this chapter, the location of a port site at VABM 28 with a short causeway and ballasted tanker would have only a relatively minor and local effect on sediment transport, and no significant effect on the Cape Krusenstern beach ridges.

Cumulative Impacts

Cumulative impacts are those which, when viewed individually, might not be significant, but which when viewed cumulatively could have significant impacts. In a project such as this, which would represent the first major development in an area, cumulative impacts would be very few by definition. Impacts which might qualify as cumulative in another area would be the first impacts within the Red Dog project area. They would therefore need to be taken into consideration during future development proposals within the region. Still, some cumulative impacts would exist.

Development of the Red Dog project, with its economic benefits including the additional people who would come into the region, would put additional pressures on existing social institutions and cultural traditions. While measures would be taken to minimize the impact on existing social and cultural patterns, particularly at the village level, the increased activity caused by project development would incrementally move the region toward a more "developed" status. While not necessarily negative, it would represent a cumulative impact to an ongoing process.

The construction of a road would ultimately make human access considerably easier to this presently isolated area. Easier access would likely result in increased use of the area by persons from outside the region for many purposes. This would likely have a cumulative impact on the subsistence use and lifestyles of the current residents within the project area.

Also, the development of a port facility on the coast with associated increased vessel traffic could cause a measure of disturbance to migrating endangered whale species. This facility, when considered with the proposed port facility at Nome, the possibility of an OCS supply base on St. Matthew Island, and the existing oil and gas activity in the Beaufort Sea, must be considered a cumulative impact.

While not recognized by recent federal or state actions for its wilderness quality, the area is de facto wilderness. Increased use of airplanes, off-road vehicles, and the exploration camps such as those which presently exist in the Red Dog Valley have all cumulatively impacted the wilderness character of the area to date. Full development of the Red Dog project with its road corridor and port site would significantly increase the cumulative impacts upon the wilderness character of the area.

UNAVOIDABLE ADVERSE IMPACTS

With one possible exception, there have been no significant adverse impacts identified by this EIS that could not be markedly reduced to minimal levels of impact by proper selection of alternatives and application of mitigation measures in the design, construction and operation of the project.

It is possible that there could be an unavoidable adverse impact upon the major caribou migration movements within the region, although this would be unlikely strictly from implementation of the Red Dog Project alone. The unpredictability of movements of this species, and the great historical changes in home range and migration of this species which have been recorded without apparent cause, make it impossible to predict the specific impact of this project. However, while construction and operation of a port and road by this project alone would likely not cause major interruptions to caribou movements, it would open a corridor to increased future traffic that might cumulatively cause such interruptions. Selection of the preferred alternative (Alternative 1) would avoid to a large extent the current primary winter habitat of caribou in the project area. Development of an appropriate monitoring program to identify and track major caribou movements, when used in conjunction with NANA's intention and authority to restrict or close operation of the road to Red Dog project activity during major movements, would probably prevent such a significant adverse impact.

SHORT-TERM USES VERSUS LONG-TERM PRODUCTIVITY

In this section the short-term uses of resources are related to the long-term effects of the project on productivity of those same resources. The purpose is to weigh the project's net benefits to residents of the project area, the region, and society as a whole. In general, short-term uses would be those which would occur during the lifetime of the project. Long-term productivity would generally refer to the time beyond the life of the project.

Estimated ore reserves of the Red Dog project area, if developed at anticipated rates, would last at least 40 years. There is a reasonable probability that additional reserves will be identified in the future which could significantly prolong the life of the project.

Many of the impacts discussed earlier in this chapter would be considered short-term, with many of the greatest impacts occurring during the initial construction and early operational phases of the project. If these impacts were properly mitigated, as also discussed, their impacts on productivity would be short-term.

Use and operation of the project facilities, particularly the road, would cause disturbance to fish and wildlife. In the long-term, depending upon the magnitude of such a disturbance, behavior and movement patterns could be significantly affected. In particular, the major seasonal caribou migrations could be interrupted, causing a major shift in location of portions of the western Arctic caribou herd. This could have a very definite long-term subsistence impact on residents of the region.

In addition to possible direct long-term impacts upon subsistence, the short-term benefits of project employment might have long-term indirect impacts upon traditional subsistence lifestyles. Increasing dependence upon the cash economy caused by project employment could lead to a lessening of participation in the subsistence lifestyle. While this would not necessarily be bad, at completion of the project villages and families might have become so dependent upon the cash economy that they would be unable to fully readapt to the subsistence lifestyle as an integral part of their existence if other types of employment were not available.

In a similar manner, the increase in economic activity, influx of new residents from outside the region, and other pressures associated with increased human populations in the short-term could have a significant impact upon existing regional social and cultural traditions and values.

In other ways, long-term productivity might be increased. The development of the project-related transportation system could lead to a long-term increase in natural resource productivity in the western Brooks Range (e.g., hard rock minerals, coal, oil and gas). An overall improvement in marine and aircraft transportation systems, with related increases in economic benefits and the efficiencies of distribution, could also accrue to the region.

If archeological and other cultural sites were properly mitigated during project development and operation, long-term knowledge of the region's earlier inhabitants would be enhanced. An adverse impact could occur, however, in the unlikely event that subsurface archeological desposits undetected in preconstruction surveys were encountered during construction. An emergency salvage plan designed for this contingency would be in place to mitigate such impact.

Also, there would be the possibility that removal of the Red Dog ore body, in conjunction with proper wastewater management and treatment measures, could significantly improve the water quality and therefore long-term productivity of Red Dog Creek itself.

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

A decision to permit the Red Dog mining project, and its subsequent construction and operation, would irreversibly and irretrievably commit several resources.

At least 85 million tons of ore, and perhaps more, would be removed and consumed. A lake would be created at the mine site in the main stem of Red Dog Creek, and the topographic features of the South Fork would be permanently altered by the creation and ultimate reclamation of the tailings pond.

If traditional caribou movements were significantly changed, and their present winter range in the project area abandoned, this could prove to be an irreversible loss.

If the southern transportation corridor location was chosen, the land status of Cape Krusenstern National Monument would likely be permanently altered by issuance of a right-of-way, or through a land exchange. In either event, the de facto wilderness nature of the project area would be permanently altered, with the loss of wilderness characteristics such as solitude and the opportunity for primitive types of recreational experiences. Also, since the Secretary of the Interior is required by Section 1317 of ANILCA to conduct a wilderness suitability study of Cape Krusenstern National Monument by December 1985, either action might preclude a significant portion of the Monument from being included in that study.

The extraction and processing of the ore would require a large commitment of energy resources (diesel oil, gasoline) which would be irretrievably consumed. Project development would require a significant input of capital both for construction and operation. Dollars spent would be irreversible and, depending upon the amount of risk involved and success of the project, possibly irretrievable.

SECTION 810, SUMMARY EVALUATION AND FINDINGS

This section was prepared to comply with Section 810 of the Alaska National Interest Lands Conservation Act of 1980 (ANILCA). It summarizes the evaluation of potential restrictions to subsistence activities which could result from the granting of a right-of-way permit pursuant to Title XI of ANILCA across Cape Krusenstern National Monument.

Only the environmentally preferred alternative as identified in Chapter III for construction of an access road to the Red Dog project has been analyzed here. Further, the portion of the route which crosses the National Monument is the focus of this section. The entire evaluation of potential effects upon subsistence activities is addressed in Chapters III and V of this Red Dog project EIS with explanation of existing baseline conditions presented in Chapter IV and in Braund & Associates (1983).

ANILCA (Public Law 96-487) provides in Section 810(a) that:

> In determining whether to withdraw, reserve, lease, or otherwise permit the use, occupancy, or disposition of public lands..., the head of the Federal agency having primary jurisdiction over such lands or his designee shall evaluate the effect of such use, occupancy, or disposition on subsistence uses and needs, the availability of other lands for the purposes sought to be achieved, and other alternatives which would reduce or eliminate the use, occupancy, or disposition of public lands needed for subsistence purposes. No such withdrawal, reservation, lease, permit, or other use, occupancy or disposition of such lands which would significantly restrict subsistence uses shall be effected until the head of such Federal agency -
>
> (1) gives notice to the appropriate State agency and the appropriate local committees and regional councils established pursuant to section 805;

(2) gives notice of, and holds, a hearing in the vicinity of the area involved; and

(3) determines that (A) such a significant restriction of subsistence uses is necessary, consistent with sound management principles for the utilization of the public lands, (B) the proposed activity will involve the minimal amount of public lands necessary to accomplish the purposes of such use, occupancy, or other disposition, and (C) reasonable steps will be taken to minimize adverse impacts upon subsistence uses and resources resulting from such actions.

ANILCA further mandates that if the federal action would significantly restrict subsistence uses and if an EIS is prepared on the federal action then the Section 810(a)(3) findings must appear in that EIS.

This section of the EIS represents a summary of the evaluation process which has occurred among the applicant, the local residents and the federal agencies.

Baseline data were collected in the summer of 1982 (Braund & Associates, 1983) to augment existing subsistence data. This information served as the basis for the evaluation of potential impacts from the alternatives considered for the project. The EIS process has served as the formal vehicle to identify potential impacts to subsistence resources and to obtain public input.

To keep residents of the villages of Noatak and Kivalina informed as to how the project might be developed, a committee of local residents was formed to review the development plans. This committee was given briefings on the development alternatives and was asked by the co-lead agencies to validate baseline data gathered in 1982.

The 810 Evaluation Process

ANILCA created new units and additions to existing units of the National Park System in Alaska. Cape Krusenstern National Monument was established by Section 201(3) as a new unit for the following purposes, among others:

> To protect and interpret a series of archeological sites depicting every known cultural period in arctic Alaska; to provide for scientific study of the process of human population of the area from the Asian Continent; in cooperation with Native Alaskans, to preserve and interpret evidence of prehistoric and historic Native cultures; to protect habitat for seals and other marine mammals; to protect habitat for and populations of, birds and other wildlife and fish resources; and to protect the viability of subsistence resources. Subsistence uses by local residents shall be permitted in the monument in accordance with the provisions of title VIII.

In addition, Title XI of ANILCA allowed for: "transportation and utility systems in and across, and access into, conservation system units as long as:

(1) such systems would be compatible with the purpose for which the unit was established; and

(2) there is no economically feasible and prudent alternative route for the system (Section 1105).

The potential for significant restriction of subsistence uses must be evaluated for the proposed action's effect upon "...subsistence uses and needs, the availability of other lands for the purposes sought to be achieved and other alternatives which would reduce or eliminate the use." Restriction of subsistence uses would be significant if there were large reductions in the abundance of harvestable resources, significant losses of habitat supporting harvestable resources, major redistributions of those resources, substantial interference with harvester access to active subsistence sites or a major increase in non-resident hunting.

By asking the following series of questions relative to the area and the proposed action, and analyzing the responses, an evaluation of significance was possible.

- Would the preferred alternative cause a significant reduction in the population of wildlife, fish, or other resources upon which subsistence harvesting depends; and/or would the preferred alternative cause a redistribution in those harvestable resources by either causing a decline in the population of wildlife or fish harvested for subsistence or by altering the distribution of those harvestable resources?

- Would the preferred alternative cause a restriction of access to the harvestable resources where harvesting historically has taken place?

- Would the preferred alternative lead to increased competition for subsistence resources?

Proposed Action on Federal Public Lands

For the Red Dog Mine project, a permit for a right-of-way through Cape Krusenstern National Monument is being sought. The National Park Service is considering this right-of-way request under Title XI of ANILCA. The application is for a 89.9 km (56.2 mi) road, 38.4 km (24.0 mi) of which would traverse the northwest corner of Cape Krusenstern National Monument. Figure II-6 shows the southern corridor (Kruz route) preferred alternative.

Affected Environment

This section reviews the subsistence activity areas which are used by the residents of Kivalina, Noatak and Kotzebue. Kivalina and Noatak are small Eskimo villages with populations of approximately 260 and 273, respectively (1982 estimates). Kotzebue is a town of approximately 2,470 and is the trade and service center for the NANA region. Figure I-1 shows the location of each population center.

Subsistence activities greatly add to the economic well being and nutrition of most of the region's residents. The extent of its importance is indicated by the findings of a 1978 survey of about one-third of the region's households. Approximately 55 percent of all households estimated they obtained half or more of their food supply by subsistence hunting, fishing and gathering (Table IV-11). This survey found that subsistence dependence was widespread throughout the region, but was much more pronounced in the outlying villages, including Kivalina and Noatak, than in Kotzebue. In a region where imported foodstuffs are costly and cash income depressed, the economic importance of the subsistence food supply is evident. Within this general pattern of reliance on subsistence, there is a great deal of variation from settlement to settlement, season to season, and year to year in subsistence harvest patterns (Social Research Institute, 1982).

The region encompasses a great diversity of terrestrial, freshwater, marine and wetland habitat types which support many valuable subsistence species. Virtually the entire region and most of its nearshore marine waters fall within the subsistence use area of one or more villages (Fig. IV-12).

Among the most important subsistence food resources are land mammals (caribou, moose), fish (Arctic char, chum salmon, sheefish, whitefish, tomcod, smelt), sea mammals (bearded, ringed and spotted seals; belukha whales) and waterfowl. However, nearly all edible animal species are used to add variety to the customary diet or in times of scarcity. Berries and other wild plant foods are also extensively gathered for consumption.

The current subsistence use areas of Kivalina and Noatak residents that overlap the project area were recently described and mapped by Braund & Associates (1983). The two communities make common use of some subsistence resource areas. However, a 1972 survey (Mauneluk Association, 1974) of overall harvest patterns found distinctive differences in the subsistence orientations of coastal Kivalina and inland Noatak residents (Table IV-12). In general, Kivalina was most heavily dependent on sea mammal and fisheries harvests, with land mammals seasonally important. Noatak residents were mostly dependent on land mammals and fisheries; sea mammals were of relatively minor importance.

The project area is part of the western Arctic caribou herd's range. Changes in the herd's migration routes and winter range conditions greatly influence hunting success.

Subsistence fishing is important to both Kivalina and Noatak residents throughout the year. The fall run of Arctic char is especially important to those communities, while the Noatak River chum salmon and char runs are important to the villages of Noatak, Kivalina and Kotzebue. Kivalina marine mammal hunters intensively search the nearshore areas off Kivalina and along the coast north and south of Kivalina in season. Both Kivalina and Noatak residents harvest waterfowl in coastal lagoons and wetlands.

Subsistence Uses and Needs Evaluation

The traditional cultural system in this region is based upon a subsistence economy which is reflected in all aspects of the social fabric. The specific evaluation of physical changes in the subsistence resources is easier to quantify than the potential modification in the subsistence lifestyle. This evaluation considers the "opportunity" for subsistence activities to occur.

To determine the potential impact on existing subsistence activities, three evaluation criteria were analyzed relative to existing subsistence resources which could be impacted. The range of potential impacts which might occur are described in Chapter V. The evaluation criteria were:

- The potential to reduce important subsistence fish and wildlife populations by a) reductions in numbers, b) redistribution of subsistence resources, or c) habitat losses;

- What effect the action might have on subsistence fisherman or hunter access;

- The potential for the action to increase fisherman or hunter competition.

The subsistence resources which are utilized in the project area include caribou, anadromous fish (specifically Arctic char), marine mammals, moose, furbearers and waterfowl. The potential impacts on subsistence are reviewed on pages V-72 through V-74. A summary of those impacts is presented below.

Arctic Char

Potential to Reduce Populations

The major Arctic char resources that could be affected within the project area exist in the Wulik and Kivalina Rivers. The southern corridor would pass no closer than 10 km (6 mi) from the Wulik River, but above Arctic char spawning areas (Fig. II-6). Along the entire southern corridor route five tributaries to the Wulik River would be crossed well away from the main stem of the Wulik River. A total of 187 stream crossings would occur along this route. Eleven of the streams crossed are fished in their lower portions. Assuming proper stream crossing techniques were used, the road would not significantly affect existing fish habitat, reduce populations or cause the redistribution of fish in the Wulik or Kivalina Rivers. In addition, the Omikviorok River, located within the National Monument, would be crossed above Arctic char spawning areas. Chapter V does not predict a significant loss of habitat, or redistribution or reduction in fish populations. Mitigation proposed to ensure reduction of impacts includes proper stream crossing location, proper crossing design, sediment control during construction, and proper construction timing.

Restriction of Fishing Access

Development of the southern corridor would not restrict fishing access. Present access to the Arctic char fishery is via river boat. The development of the roadway would not reduce present access available to subsistence fishermen in the Wulik, Kivalina or Omikviorok Rivers.

Increase in Fishing Competition

The NANA/Cominco agreement gives as one of its goals 100 percent Native hire for the Red Dog project. The employees would come from surrounding villages and would live in a hotel-type complex accommodation. Workers would be employed on a shift basis which would call for them to return to the villages on a regular basis. No new town would be developed as part of the Red Dog project. Chapter V states that only limited population growth would occur, and this is not anticipated to have a significant effect on fishing competition. Chapter V states the applicant's decision to mitigate possible impacts by restricting fishing activities of project personnel while on duty in order to protect traditional subsistence values.

The route would be public in that it would be available for use by other future resource developments in the region (but not by the general public).

Caribou

Potential to Reduce Subsistence Wildlife Populations

Development of the entire southern road corridor would eliminate 201 ha (497 ac) of caribou habitat. This direct loss of habitat would result in an insignificant loss of caribou habitat within the project area.

Without proper management and precautions, indirect habitat loss would likely be significant for caribou on a local basis, and could even be of greater than local significance. The southern corridor passes between current primary caribou low tussock tundra winter range in the Wulik and Kivalina lowlands, and secondary winter range on the more windswept slopes of the Mulgrave Hills to the southeast (Fig. IV-5). Road activity would cause avoidance of the corridor, and hence displacement, thereby limiting to some extent the use of otherwise available winter habitat. There could also be some mortality due to vehicle collisions or added stress from winter traffic. Chapter V states that, based upon experience with other roads in Alaska and the Arctic in general, the approximately 20 to 25 vehicle round trips per day (excluding maintenance) associated just with the Red Dog project would be unlikely to cause a major shift in movement patterns.

To maximize the possibility that road construction and operation would not affect the distribution of caribou, a specific monitoring plan would be developed to track major movements and make project activity suspension decisions. This plan would be established before actual construction begins so adequate baseline data would be available. Therefore, road construction and operation should not result in a significant loss of habitat or result in a redistribution of the caribou herd.

Effect on Hunter Access

Chapter V states that development of a road would not limit access to subsistence activities.

Increase in Hunter Competition

The impact for caribou would be essentially the same as for Arctic char as described above.

Marine Mammals

Marine mammal hunting is generally confined to the winter and spring months when the port would be ice-bound, so ship traffic from the port should not significantly disrupt harvest activities. However, port construction and year-round activities aboard the offshore transfer facility would likely displace some marine mammals from the immediate area, resulting in a reduction in size of the local marine mammal harvest area. Any mishaps such as episodic or chronic spillage of fuels or chemicals that could seriously damage habitat quality might adversely affect marine mammal populations. However, the net impact of ordinary port operations on marine mammal resource availability would not be significant. Pages V-55 to V-57 provide a more detailed discussion of potential impacts.

Other Subsistence Resources

Chapter V reviews the potential effects to furbearers, moose and waterfowl. The level of impact from development of the southern corridor is considered insignificant. (See pages V-72 through V-74.)

Availability of Other Lands

The development of the Red Dog lead/zinc deposit is the impetus behind the analysis of alternatives for developing an access road to remove the metal concentrates. The location of the deposit determines the area which would be considered for potential development. This document has reviewed and evaluated all reasonable options to provide access to the mine. It has identified the environmentally preferred alternative which has been the subject of this Section 810 compliance review. Pages III-8 through III-51 review how the preferred alternative was identified.

The only alternative identified which would use another corridor and port site, Alternative 2, would have greater subsistence impacts than the preferred alternative. Pages V-73 and V-74 provide a more detailed discussion of those potential impacts.

Alternatives Considered

Table III-9 identifies the options which were used to form the project alternatives. Figure III-3 identifies the alternatives considered for the Red Dog project. Alternative 1 was selected by the co-lead agencies as the preferred alternative and has been the subject of this Section 810 compliance review.

Consultation and Coordination

The following individuals and their respective agencies have been consulted on this Section 810 Summary Evaluation. Their comments were noted and in most cases incorporated into this section as part of the EIS consultation process.

- FWS - Robert Leedy
- EPA - William Riley
- ADF&G - Steve Behnke, Richard Stern
- BLM - Laun Buoy
- Corps - Joe Williamson

Findings

Based upon the above process and considering all the available information, this evaluation could not forecast any reasonable foreseeable events that would entail a significant restriction of subsistence use.

VI. SUMMARY OF PERMIT AND REGULATORY PROGRAMS

INTRODUCTION

One of the purposes of an Environmental Impact Statement process is to address the environmental and other concerns of federal, state and local agencies responsible for the various regulatory functions associated with ultimate approval of a project. The EIS process recognizes the informational needs of these agencies as they proceed through their permitting processes and seeks to incorporate relevant information to assist those agencies in their permitting decisions. The public hearings, which are an integral part of the EIS process and cover all concerns pertinent to the project, also serve as public participation forums for state and federal permitting processes.

The major federal, state and local permits, contracts and other approvals required for development of the Red Dog project are described in Table VI-1. How each of these is addressed in this EIS is briefly discussed below. These descriptions are not detailed and are only meant to give the reader a general idea of how the EIS process complements the various individual permitting processes.

FEDERAL APPROVALS

NPDES Permit (EPA)

The EIS describes the existing water quality and quantity conditions in the project area; the expected pollutants, concentrations, quality and locations of wastewater treatment facilities and discharges; and the expected impacts resulting from discharges. It identifies the type and location of the various project components, and also describes the process by which they were sited. The EIS discusses the need for monitoring of water quality during operation of the project and generally describes the type of monitoring program that might be used. It also discusses reclamation plans and the need to ultimately discharge water in order to reclaim the tailings pond. A copy of the Draft NPDES Permit, fact sheet and public notice are included in Appendix 4. A second NPDES Permit (separate from the major permit) would be required for the port facility.

Department of the Army (Section 404 - dredged or fill material) Permit Review (EPA)

The same information provided by the EIS which is needed by the Corps in its Clean Water Act Section 404 permitting process (discussed below) is also

Table VI-1

MAJOR FEDERAL, STATE AND LOCAL PERMITS, CONTRACTS OR OTHER APPROVALS REQUIRED FOR PROJECT DEVELOPMENT

Regulated Activity (Required Approval)			
Federal Authority	Regulatory Agency	Authority	Description
Waste discharge into a waterway (National Pollutant Discharge Elimination System [NPDES] Permit)	U. S. Environmental Protection Agency (EPA)	Section 402, Federal Water Pollution Control Act of 1972, as amended in 1977 (Clean Water Act) (33 USC 1251)	EPA must authorize any activity or wastewater system which would discharge waste from one or more points into a waterway.
Discharge of dredged or fill material into U.S. waters, including wetlands (Review of Corps' Department of Army Section 404 Permit)	EPA	Section 404, Federal Water Pollution Control Act of 1972, as amended in 1977 (Clean Water Act) (33 USC 1344)	EPA reviews Corps' Department of Army Section 404 Permit under its Section 404(b)(1) "Guidelines for Specifications of Disposal Sites for Dredged or Fill Material".
Discharge of dredged or fill material into U.S. waters, including wetlands (Department of Army Permit)	U. S. Army Corps of Engineers (Corps)	Section 404, Federal Water Pollution Control Act of 1972, as amended in 1977 (Clean Water Act) (33 USC 1344)	The Corps must authorize the discharge of dredged or fill material into U. S. waters, including wetlands. Includes siting of facilities, roads, etc. Corps determines compliance with the Section 404(b)(1) guidelines.
Construction of structures or work in or affecting navigable waters of the U.S. (Department of Army Permit)	Corps	Section 10, River and Harbor Act of 1899 (33 USC 403)	The Corps must authorize: the construction of any structure in or over navigable waters of the U. S.; the excavation of material in such; or the accomplishment of any other work affecting the course, location, condition or capacity of such waters.
Construction of transportation system in and across conservation system unit (Right-of-Way Permit for Transportation System)	U. S. National Park Service (NPS)	Title XI, Alaska National Interest Lands Conservation Act of 1980 (ANILCA) (16 USC 3161)	NPS must determine that a proposed transportation system would be compatible with the purposes for which the conservation unit was established, and that there is no economically feasible and prudent alternative route for the system.
Construction of transportation system in and across conservation system unit (NPDES Permit and Department or Army Permit, respectively)	EPA & Corps	Title XI, Alaska National Interest Lands Conservation Act of 1980 (ANILCA) (16 USC 3161)	EPA, Corps & NPS would concurrently issue their respective permits for the transportation system.

Table VI-1

(Continued)

MAJOR FEDERAL, STATE AND LOCAL PERMITS, CONTRACTS OR OTHER APPROVALS REQUIRED FOR PROJECT DEVELOPMENT

Regulated Activity (Required Approval)	Regulatory Agency	Authority	Description
Federal Authority (Continued)			
Use, occupancy or disposition of public lands having subsistence uses (Subsistence Compliance Findings)	NPS	Section 810, Alaska National Interest Lands Conservation Act of 1980 (ANILCA) (16 USC 3120)	NPS must determine if issuance of a Title XI ROW would significantly restrict subsistence uses. If it would, a finding must be made that: such ROW is necessary and consistent with sound management principles; it would involve the minimal amount of lands necessary; and reasonable steps would be taken to minimize impacts on subsistence resources.
Development possibly affecting threatened or endangered terrestrial plant or animal species (Section 7 Consultation)	U. S. Fish & Wildlife Service (FWS)	Section 7, Endangered Species Act of 1973, as amended (16 USC 1531)	If threatened or endangered terrestrial or fresh-water plant or animal species were determined to be present in the project area, biological assessments of potential impacts to those species would be required. If impacts were anticipated, a formal Section 7 consultation with FWS would be required to determine conditions under which the project should be permitted.
Development possibly affecting threatened or endangered marine fish, reptile and mammal species (Section 7 Consultation)	U. S. National Marine Fisheries Service (NMFS)	Section 7, Endangered Species Act of 1973, as amended (16 USC 1531)	Same as above, except for marine fish, reptile and mammal species, and consultation with NMFS.
Development possibly affecting historical or archeological sites (Review and Comment)	Advisory Council on Historical Preservation (ACHP)	National Historic Preservation Act of 1966, as amended (16 USC 470)	ACHP must be given a reasonable opportunity to review and comment on the adequacy of the management plan for historic or archeological sites potentially impacted by any federally permitted or licensed project. This may include concurrence with a Memorandum of Agreement among the appropriate federal agency, the SHPO and the ACHP.
Occupancy and modification of floodplains (Floodplain Management Considerations)	All federal agencies	Executive Order 11988 (Floodplain Management) May 24, 1977	All federal agencies must avoid, to the extent possible, adverse impacts associated with occupancy and modifications of floodplains, including direct or indirect support of floodplain development whenever there is a practicable alternative.

Table VI-1

(Continued)

MAJOR FEDERAL, STATE AND LOCAL PERMITS, CONTRACTS OR OTHER APPROVALS REQUIRED FOR PROJECT DEVELOPMENT

Regulated Activity (Required Approval)	Regulatory Agency	Authority	Description
Federal Authority (Continued)			
Destruction or modification of wetlands (Wetlands Protection Considerations)	All federal agencies	Executive Order 11990 (Protection of Wetlands) May 24, 1977	All federal agencies must avoid, to the extent possible, adverse impacts associated with destruction and modification of wetlands, including direct or indirect support of new construction in wetlands wherever there is a practicable alternative.
State of Alaska Authority			
New sources of air pollution (Air Quality Permit to Operate) (Prevention of Significant Deterioration [PSD] Permit)	Department of Environmental Conservation (DEC)	AS 46.03.140 to .170 Clean Air Act of 1963, as amended (42 USC 1857)	DEC must authorize plans and specifications for construction that would be undertaken and must assess emission standards and possible air contamination resulting from that construction. As of July 1983, the Prevention of Significant Deterioration (PSD) Permit formerly granted by EPA was incorporated under DEC's authorization.
Discharge into navigable waters (Certificate of Reasonable Assurance)	DEC	Section 401, Federal Water Pollution Control Act of 1972, as amended in 1977 (Clean Water Act) (33 USC 466)	DEC must issue a certificate stating that the proposed activity would comply with the requirements of the Federal Water Pollution Control Act. Completion of all federal permits, including NPDES, Section 404 and Section 10, would depend upon DEC's granting of a Certificate of Reasonable Assurance.
Wastewater discharge into all waters of the state (Wastewater Disposal Permit)	DEC	AS 46.03.090 to .110 AS 46.03.720	DEC must authorize the discharge of wastewater into or upon all waters or land surface of the state. Includes review and approval of treatment facility plans. For projects requiring a federal Section 402 (NPDES) Permit, DEC's Certificate of Reasonable Assurance serves as the Wastewater Disposal Permit.
Solid waste disposal (Solid Waste Disposal Permit)	DEC	AS 46.03.020 AS 46.03.100	DEC must authorize plans, specifications and proposed methods of operation for a facility to dispose of solid waste.
Alteration of stream flow (Title 16, Anadromous Fish Stream Permit)	Department of Fish and Game (ADF&G)	AS 16.05.840 AS 16.05.870	ADF&G must approve methods and schedule of any project which would alter the natural flow or bed, or use equipment in specified anadromous rivers, lakes, or streams.

Table VI-1

(Continued)

MAJOR FEDERAL, STATE AND LOCAL PERMITS, CONTRACTS OR OTHER APPROVALS REQUIRED FOR PROJECT DEVELOPMENT

Regulated Activity (Required Approval)	Regulatory Agency	Authority	Description
State of Alaska Authority (Continued)			
Transportation across state lands (Right-of-Way Permit)	Department of Natural Resources (DNR)	AS 38.05.035 AS 38.05.330	DNR must issue a right-of-way or easement permit for any road, pipeline, transmission line or other improvement that crosses state lands.
Use of public water (Water Rights Permit)	DNR	AS 46.15.030 to .185	DNR must issue a permit before appropriation of state waters can be made. Once use of appropriated water has commenced, rights to that water can be secured by a "Certificate of Appropriation".
Dam construction (Dam Safety Permit)	DNR	AS 46.15.020 to .180	DNR must approve construction of any dam structure over 3 m (10 ft) high or which impounds over 62 dam^3 (50 ac-ft) of water.
Temporary use of tidelands (Tidelands Use Permit)	DNR	AS 38.05.330	DNR must grant a one year land use permit for use of tidelands for nonrecurring activities which do not involve permanent structures.
Permanent use of tidelands (Tidelands Lease)	DNR	AS 38.05.330 AS 38.05.070 to .300	DNR must issue a tidelands lease for projects involving permanent structures on tidelands. Issuance of lease would be competitive.
Materials (gravel) sale (Materials Sale Contract)	DNR	AS 38.05.110	DNR must issue a Materials Sale Contract for use of gravel or other materials from state lands. Volumes over 19,114 m^3 (25,000 yd^3) would be sold by competitive bid.
Development possibly affecting historic or archeological sites (Cultural Resources Concurrence)	Office of History and Archeology/State Historic Preservation Office (SHPO)	National Historic Preservation Act of 1966, as amended (16 USC 470) AS 41.35.010 to .240, Alaska Historic Preservation Act	For any federally permitted, licensed or funded project, the SHPO must concur that cultural resources would not be adversely impacted, or that proper methods would be used to minimize or mitigate impacts which would take place. Concurrence must be received before federal permits can be granted.
Development within the coastal zone (Coastal Zone Management Consistency Determination)	Governor's Office of Management and Budget (OMB), Division of Governmental Coordination	Coastal Zone Management Act of 1972, as amended in 1976 (16 USC 1451) AS 46.40 Alaska Coastal Management Program Act of 1977	OMB must concur with the applicant's Coastal Zone Management Consistency Determination that, to the extent practicable, a development project would be consistent with the approved State Coastal Zone Management Plan.

Table VI-1

(Continued)

MAJOR FEDERAL, STATE AND LOCAL PERMITS, CONTRACTS OR OTHER APPROVALS REQUIRED FOR PROJECT DEVELOPMENT

Regulated Activity (Required Approval)	Regulatory Agency	Authority	Description
Local Authority			
Major project development (Land Use Permit)	North Slope Borough (NSB)	Title 19, North Slope Borough Municipal Code	NSB must issue a land use permit indicating the proposed project would be consistent with the approved Master Plan.

used by the EPA for its Section 404(b)(1) review of Corps Section 404 Permit applications.

Title XI Application Review (EPA)

The same information provided by the EIS which is needed by the NPS for its Title XI review and permitting responsibilities is also used by EPA for its Title XI review and permit responsibility.

Department of the Army (DA) Permit (Corps)

The Corps issues a DA Permit that combines its authorities under Section 404 (dredged or fill material) and Section 10 (navigable waters). To address the Section 404 requirements the EIS identifies the existing waterways and wetlands within the project area, and describes the various wetlands types and their importance from functional and productivity standpoints. It describes the type and location of project components, and also describes the process by which they were sited. The EIS identifies the type and amount of wetlands and other waters that would be impacted by each alternative, and discusses mitigating measures that might be used to minimize waters or wetlands impacts. It also describes reclamation plans. The Corps evaluation of compliance with Section 404(b)(1) guidelines is included as Appendix 5.

To address the Section 10 requirements, the EIS describes the existing navigable waters within the project area and how the project components would affect them. It discusses the types of facilities, the process by which they were sited, and how they would be constructed and operated. The EIS describes the various options (e.g., short causeway/lightering versus short causeway/offshore island), and compares them with respect to impacts upon the integrity of the coastline and sediment movements past the facilities. It also discusses mitigative measures to minimize impacts, and reclamation of the structures.

Title XI Application Review (Corps)

The same information provided by the EIS which is needed by the NPS for its Title XI review and permitting responsibilities is also used by the Corps for its Title XI review and permit responsibility.

Title XI Right-of-Way Permit (NPS)

The EIS describes the existing land status situation within the project area and the potential impacts of various project components on Cape Krusenstern National Monument. It discusses the transportation corridor, port site and transfer facility options individually and describes the process by which the alternatives were identified and the preferred alternative selected. A copy of the Title XI Application is included in Appendix 6. The NPS would be the agency that would actually issue the right-of-way permit for the transportation corridor.

Section 810 Subsistence Compliance Findings (NPS)

The EIS describes the subsistence resources in the vicinity of the southern corridor, within the Monument and in surrounding areas, as well as their uses by time and location. It describes the significance of potential impacts to subsistence resources and uses from a corridor through the Monument as well as alternative corridors that avoid the Monument. It describes mitigative measures that would be taken to minimize adverse impacts upon subsistence uses and resources, and it discusses the reasons why selection of the preferred alternative through the Monument is consistent with sound land management principles. The Section 810 Subsistence Compliance Findings are contained near the end of Chapter V.

Section 7 (Endangered Species) Consultations (FWS and NMFS)

The EIS process identified the endangered peregrine falcon as nesting within the project area. This finding required that a biological assessment be prepared to determine if the project might affect this species. The assessment was prepared and submitted to FWS.

The EIS process also identified the endangered bowhead and Gray whales as using the area off the proposed port sites during migration. This finding required that a biological assessment be prepared to determine if the project might affect these species. The assessment was prepared and submitted to FWS. A more detailed discussion of endangered species considerations is included in Appendix 3 (Endangered Species Biological Assessment).

Historic and Archeological Review and Comment (ACHP)

The EIS identifies the reports and other documents that describe known archeological and other cultural resources which might be impacted by the project. It also discusses potential impacts and suggests mitigative measures to be taken to protect historic and archeological resources. Correspondence between the ACHP and co-lead agencies is included in Appendix 7 (Protection of Cultural Resources).

Floodplain Management Considerations (All Federal Agencies)

The EIS identifies existing floodplains within the project area, locates the various project options as being within or outside those floodplains, and describes the potential impacts of facilities located within floodplains. This information is used by all federal agencies for their floodplain management considerations as required by Executive Order 11988.

Wetlands Protection Considerations (All Federal Agencies)

The same information provided by the EIS which is needed by the Corps in its Section 404 permitting process (discussed earlier) is also used by other federal agencies for their wetlands protection considerations as required by Executive Order 11990.

STATE APPROVALS

Air Quality Permit to Operate (DEC)

The EIS describes the existing air quality conditions and parameters, as well as the quality and quantity of pollutants that would be emitted from the facilities. Analysis of this information would indicate whether a Prevention of Significant Deterioration (PSD) Permit would be required. Additional baseline information and analyses would likely be needed after completion of the EIS before the permit could be issued.

Certificate of Reasonable Assurance (DEC)

The EIS provides analysis of hydrology and water quality baseline conditions and predicts the hydrology and water quality of receiving streams during operation and after reclamation. Water quality monitoring would continue through the life of the project to verify the water quality projections made in the EIS. Refer to the NPDES description for additional details.

The same information provided by the EIS which is needed by the Corps for its Sections 404 and 10 permitting processes (discussed earlier) is also used by DEC in its consideration of issuance of a Certificate of Reasonable Assurance.

An NPDES permit with the required state Certificate of Reasonable Assurance, when issued, serves as the state wastewater disposal permit for projects such as Red Dog. DEC may issue individual wastewater permits for small discharges which do not require an NPDES permit. The EIS describes the mine area wastewater treatment process. Estimates are provided for the type and concentrations of all significant water quality parameters in the tailings pond, and for the projected water quality of the treated effluent. A complete water balance for the mill process and the tailings pond is provided as the basis for these projections.

Solid Waste Disposal Permit (DEC)

Some elements of a solid waste disposal plan (e.g., tailings pond location, overburden disposition) are presented in the EIS. Incineration would be used for all wastes whose burning would not violate air quality restrictions. Other wastes would be incorporated in the tailings pond. The ultimate disposal of buildings and discarded equipment would be determined near the time of mine closure.

Title 16 (Anadromous Fish Stream) Permit (ADF&G)

Streams containing anadromous fish within the project area are identified in the EIS, and the locations of project components which might affect them are described (e.g., impoundment and drainage structures, bridge crossings, port facilities). Design, construction and operational measures are suggested to mitigate potential impacts.

Right-of-Way Permit (DNR)

Descriptions and maps, including land ownership status, are provided in the EIS for proposed transportation corridors across state lands. Detailed plans for the selected road corridor would be provided after completion of the EIS process and additional field surveys.

Water Rights Permit (DNR)

The EIS provides detailed descriptions of the location and type of proposed water diversions, and estimated amounts of water consumption.

Dam Safety Permit (DNR)

The EIS describes the location, size and general composition of the tailings pond and water supply dams and associated impoundments.

Tidelands Use Permit (DNR)

A conceptual plan for tidelands use during project mobilization and construction of the dock and offshore island is presented in the EIS. Detailed construction plans concerning dredging, fill and grading would be provided after the EIS process has identified the location and type of facilities.

Tidelands Lease (DNR)

Plans for the long-term use of tidelands facilities would be provided to DNR after completion of the EIS process.

Materials Sale Contract (DNR)

The location and size of alternative project components requiring gravel for construction are identified in the EIS. Detailed information about the amounts and location of gravel or rock needed from state lands would be developed by field survey after the EIS process has determined the specific facility and route locations.

Cultural Resources Concurrence (SHPO)

The EIS identifies the reports and other documents that describe known archeological and other cultural resources which might be impacted by the project. It also discusses potential impacts and suggests mitigative measures to be taken to protect cultural resources. Correspondence between the SHPO and co-lead agencies is included in Appendix 7 (Protection of Cultural Resources).

Coastal Zone Management Consistency Determination (OMB)

The EIS provides a sufficient description of the location, type and operation of the proposed road corridor, port site and marine transfer facilities to allow OMB to review the applicant's determination of consistency with the approved State Coastal Zone Management Plan. A draft Coastal Zone Management Plan has been prepared for the NANA region, but the state master plan will be followed until the regional plan is finalized. If the State's response to the applicant's consistency determination is available, it will be included in the FEIS.

LOCAL APPROVALS

Land Use Permit (NSB)

The EIS describes the locations and types of project facilities, the process by which they were sited, and some of the solid waste disposal plans. It also points out potential environmental impacts which might be of specific concern to the Borough (e.g., possible effects upon endangered whale migration movements). Detailed construction plans and specifications would be provided for individual project elements after completion of the EIS.

VII. CONSULTATION AND COORDINATION

INTRODUCTION

A designated purpose of an EIS is to actively involve regulatory agencies and the public in the decision-making process. EPA and DOI, as co-lead agencies, conducted a broad public and interagency consultation and coordination program throughout the development of this DEIS. Input was solicited from the beginning of the project, and this input has been incorporated into the document. Specific public and agency involvement is described below.

SCOPING

The scoping process conducted by EPA provided an opportunity for members of the public, special interest groups, and agencies involved in the EIS process to assist in defining significant environmental issues. Main objectives of these scoping meetings were:

- To present an overview of the proposed Red Dog Project;
- To identify the major environmental issues to be addressed in the EIS;
- To receive comments and questions regarding environmental impact concerns; and
- To incorporate those comments and questions into the EIS planning process.

The scoping meetings, and the approximate number of persons in attendance, were as follows:

Date	Location	Attendance	Participants
Feb. 14, 1983	Anchorage	10	Alaska Center for the Environment; Trustees for Alaska; National Audubon Society; public
Feb. 16, 1983	Fairbanks	34	State and federal agencies
"	"	7	Northern Environmental Center
"	"	16	Public meeting

Date	Location	Attendance	Participants
Mar. 9, 1983	Kotzebue	34	Maniilaq Association; state, federal, and local agencies; public
"	"	15	Public meeting
Apr. 1, 1983	Barrow	7	North Slope Borough

The oral and written comments and questions received during and following the scoping meetings were documented in a Responsiveness Summary (EPA, 1983). Its purpose was to provide a public record of the issues and concerns raised, to provide a response to those issues and concerns, and to serve as a blueprint for the EIS process to follow. A summary of the comments received at the scoping meetings and from written responses is shown in Table VII-I.

AGENCY INVOLVEMENT

The federal, state and local agencies involved with this EIS and the nature of their involvement is described in Chapter VI (Summary of Permit and Regulatory Programs). The first formal agency meeting was held February 16, 1983 in Fairbanks. Agency involvement has continued throughout the study via: 1) formal review of the Responsiveness Summary and issue identification process; 2) field visits to the Red Dog project site; 3) an August 10, 1983 meeting to describe the options elimination and project alternatives selection process; 4) agency review of a preliminary draft of the DEIS and a November 3, 1983 meeting to discuss the draft; and 5) informal phone calls between EIS team members and agency personnel and the public.

In addition, the Corps is a formal cooperating agency for the EIS, as provided for in the Council or Environmental Quality Regulations governing preparation of an EIS. As such, the Corps provided throughout the EIS process technical assistance in its area of expertise and in matters relating to permits within its jurisdiction.

PUBLIC INVOLVEMENT

Public meetings were held in Anchorage, Fairbanks and Kotzebue in February and March, 1983. In addition, meetings were also held with environmental groups in Anchorage and Fairbanks during that time period. Comments from the general public and these groups were documented and addressed in the Responsiveness Summary (Table VII-1).

Environmental groups in Anchorage and Fairbanks reviewed a preliminary draft of the DEIS, and a meeting with these groups was held on November 4, 1983 to discuss that draft.

Table VII-1

MATRIX OF COMMENTS RECEIVED FROM SCOPING MEETINGS AND WRITTEN RESPONSES

Issue	Comment Sources																Summary	
	Meetings						Written Comments											
	Anch. Environ. Groups	N. Environ. Center	Manillaq Association	Fairbanks Public	Kotzebue Public	Public	N. Slope Borough	Nat'l Park Service	Bur. Land Management	Fish & Wildlife Service	Corps of Engineers	Nat'l Marine Fish. Service	Dept. Natural Resources	Dept. Fish & Game	Dept. of Transportation	Dept. Environ. Conserv.	Comments	Sources
A. PHYSICAL ENVIRONMENT																		
1. Water:																		
Quality	3		1	2		3	4	1	1	8			3	5		4	35	11
Appropriation													1				1	1
2. Littoral Processes	1	1						2	2	1		1	1	1		1	11	9
3. Air Quality		1								1							2	2
B. BIOLOGICAL ENVIRONMENT																		
1. Vegetation & Wetlands	1	1								1							3	3
2. Freshwater Biology	2									2		1	5	4		2	16	6
3. Marine Biology		2	3							4		2		3		3	17	6
4. Wildlife	3	1	3	1			1		2	4				6			21	8
C. HUMAN ENVIRONMENT																		
1. Employment:																		
Opportunities			8		3		1										12	3
Conditions	1		2		3		1										7	4
2. Economic	1		9		2												12	3
3. Social/Cultural			10		1												11	2
4. Subsistence	1		2				1	1	1	2							8	6
5. Archeology				2				2		2							6	3
6. Local Government			1				1										2	2
7. Land Use	1									1							2	2
8. Visual	1																1	1
9. Recreation			2							1							3	2
D. PROJECT DESIGN & CONSTRUCTION																		
1. Port & Housing Facilities	1						1					2					4	3
2. Blasting														1			1	1
3. Mill Processes										1							1	1
4. Tailings Pond & Dam	1						1			2							4	3
5. Wastewater Treatment																2	2	1
6. Transportation System	2	1	4		1					2		1	3	1		1	16	9
7. Spills	1															4	5	2
8. Economics		1	1		1		1										4	4
9. Mitigation & Reclamation	3		1	1	1					1							7	5
E. EIS PROCEDURES																		
1. General Comments							1		2	2	3			1			9	5
2. Address All Options	2							2		3	1			2	1		11	6
3. Regional Perspective:																		
Accommodate Others	1						1	1		4	1		3	3	1	1	16	9
Secondary Impacts	2		1											1			4	3

FUTURE PARTICIPATION

Future public participation aspects of the Red Dog EIS process will include:

- Ongoing public involvement through the submission of questions, information and the expression of concerns, which are welcome at any time (see the agency contact addresses below).
- The formal period for public review and written comments will occur following publication of this DEIS.
- Public meetings/hearings to discuss updated project status, answer questions and receive comments will be held during the DEIS review period. All written comments received during the DEIS review period will be individually addressed in the final EIS.

TENTATIVE EIS SCHEDULE

The following is a tentative schedule for the remainder of the Red Dog Project EIS process:

Public hearings on DEIS: April 24, May 2-3, 1984
Close of public comment period: May 14, 1984
FEIS distributed for review: July 13, 1984
Close of public comment period on FEIS: August 12, 1984
Record of Decision published: August 26, 1984

PROJECT INFORMATION CENTERS

Project information and related documents such as the baseline studies, the project overview, and the draft EIS with appendices (when completed) are available for review during normal business hours at the EPA and Ott Water Engineers offices listed above, and also at the following locations:

Z. J. Loussac Library
524 West 6th Avenue
Anchorage, AK 99501

Noel Wien Public Library
1215 Cowles
Fairbanks, AK 99701

Maniilaq Association Offices
Shore Street
Kotzebue, AK 99752

Environmental Protection Agency
3200 Hospital Drive, Suite 101
Juneau, AK 99801

AGENCY CONTACTS

For additional information or submittal of questions and concerns relating to the proposed Red Dog Project or the EIS, please contact:

EPA

William M. Riley
EIS Project Officer
Environmental Evaluation Branch
(M/S 443)
Environmental Protection Agency
1200 Sixth Avenue
Seattle, WA 98101
Telephone: (206) 442-1760

DOI

Paul D. Gates
Regional Environmental Officer
Department of Interior
Box 100120
Anchorage, AK 99510
Telephone: (907) 271-5011

EIS Third Party Consultant

Michael C. T. Smith
Project Manager
Ott Water Engineers, Inc.
4790 Business Park Blvd.
Building D, Suite 1
Anchorage, AK 99503
Telephone: (907) 562-2514

VIII. LIST OF PREPARERS

U.S. ENVIRONMENTAL PROTECTION AGENCY (Lead Agency)

William M. Riley
Red Dog EIS Project Officer

U.S. NATIONAL PARK SERVICE

Floyd Sharrock
Special Assistant

OTT WATER ENGINEERS, INC. (Third Party EIS Consultant)

Name	Responsibility/Discipline
Michael C. T. Smith, Ph.D. (Terra Nord, Inc.)	Project Manager and Wildlife
Roderick W. Hoffman, Ph.D.	OTT Project Manager, Freshwater and Marine Biology
Joanne E. Richter, M.S.	Assistant Project Manager and Editor
James K. Barrett, M.S.	Groundwater Hydrology
Patricia Bendz	Draftsperson
Sandra L. Christy, M.S.	Vegetation and Recreation
Gene R. Crook, M.S., P.E.	Marine Water and Wastewater Quality
Dennis E. Dorratcague, M.S., P.E.	Coastal Geologic Processes
John H. Humphrey, Ph.D., P.E.	Surface Water Quality and Hydrology, Air Quality, Sound and Visual Resources
Arthur J. LaPerriere, Ph.D.	Vegetation
Anne S. Leggett, B.A.	Proofer

Name	Responsibility/Discipline
John E. Lobdell, Ph.D.	Cultural Resources
James G. Malick, Ph.D. (Norecol Environmental Consultants)	Fishery Resources
William L. Ryan, Ph.D., P.E.	Geological, Geotechnical and Permafrost
Kevin Waring, B.A. (Kevin Waring Associates)	Subsistence and Socioeconomics

ROSS & MOORE ASSOCIATES, INC. (Word Processing)

Marilee Moore Bourne
Tami Jean Fillbrandt
Judith Ross Fowler

ADDITIONAL STUDIES, REPORTS AND INFORMATION CONTRIBUTED BY:

Gerald G. Booth, Cominco Alaska, Inc.
Henry M. Giergich, Cominco Alaska, Inc.
Walter J. Kuit, Cominco Alaska, Inc.
Terry J. Mannings, Cominco Alaska, Inc.
Harry A. Noah, Cominco Alaska, Inc.
James A. Rae, Cominco Alaska, Inc.

Stephen R. Braund & Associates
Dames & Moore
Thomas J. Gallagher
Edwin E. Hall & Associates
Larry A. Peterson & Associates
R & M Consultants
Woodward-Clyde Consultants

IX. EIS DISTRIBUTION LIST

The following list of recipients of the EIS is arranged with federal agencies first, followed by state agencies, local agencies, media, interested groups and businesses and citizens.

FEDERAL AGENCIES

U.S. Environmental Protection Agency

Office of Environmental Review EIS Filing Section

Alaska Operations Office

Office of Federal Activities

Regional Offices

U.S. Department of the Interior

Office of Environmental Project Review, Washington, D.C.
  Regional Environmental Officer, Anchorage

Office of Assistant to the Secretary of the Interior

Bureau of Land Management
  State Director's Office, Anchorage
  Fairbanks District Office
  Minerals Management Service, Denver, CO
  Bureau of Indian Affairs, Juneau

U.S. Fish and Wildlife Service
  State Director's Office, Anchorage
  Fairbanks District Office
  Selawik National Wildlife Refuge

National Park Service
  Regional Director's Office, Anchorage
  Cape Krusenstern National Monument
  Denali National Park and Preserve
  Denver Service Center

Alaska Resources Library

U.S. Department of Commerce

National Marine Fisheries Service, Anchorage
   Director's Office, Juneau

National Oceanic and Atmospheric Administration, Juneau

Federal Highway Administration, Juneau

Office of Coastal Management, Washington, D.C.

U.S. Department of Agriculture

Coordinator of Environmental Quality, Washington, D.C.

Soil Conservation Service, Anchorage

U.S. Forest Service, Juneau

U.S. Department of Transportation

U.S. Coast Guard, Anchorage

U.S. Department of Defense

Department of the Army, Alaska District, Corps of Engineers, Anchorage
   District Engineer
   Regulatory Functions Branch
   Environmental Resources Section

Department of the Army, North Pacific Division, Corps of Engineers, Portland, OR

U.S. Department of Health and Human Services

Regional Environmental Officer, Seattle, WA

Advisory Council on Historic Preservation, Washington, D.C.

U.S. Federal Energy Regulatory Commission

Regional Office, San Francisco, CA

U.S. Department of Housing and Urban Development, Anchorage

U.S. Congress

Honorable Ted Stevens, U.S. Senator

Honorable Frank Murkowski, U.S. Senator

Honorable Don Young, U.S. Congressman

JOINT FEDERAL/STATE

Alaska Land Use Council

State Co-Chairman

Federal Co-Chairman

STATE AGENCIES

Office of the Governor

Honorable William Sheffield, Governor

Office of Management and Budget, Division of Governmental Coordination

Governor's Office, Kotzebue

Department of Environmental Conservation

Commissioner's Office, Juneau

Northern Regional Office, Fairbanks

Nome Area Office

Water Quality Management Office, Juneau

Department of Fish and Game

Commissioner's Office, Juneau

Habitat Protection Division, Fairbanks

Nome Regional Office

Kotzebue Area Office

Department of Natural Resources

Commissioner's Office, Juneau

Division of Land and Water Management, Anchorage

Northcentral District Office, Fairbanks

State Historic Preservation Office, Anchorage

Division of Mining, Anchorage

Department of Transportation and Public Facilities

Commissioner's Office, Juneau

Regional Environmental Coordinator, Fairbanks

Office of Planning, Fairbanks

Department of Community and Regional Affairs

Division of Community Planning, Juneau

Department of Commerce and Economic Development

Office of Minerals Development

Department of Revenue

Commissioner's Office

Department of Labor, Juneau

Commissioner's Office

Department of Law

Office of the Attorney General, Juneau

LOCAL AGENCIES

Mayor Clement Frankson, Sr., Point Hope
Mayor Amos Agnasagga, Point Lay
IRA Council, Noatak
Ukpeagvik Inupiat Corporation, Barrow
Mayor Raymond Hawley, Kivalina
Tagara Village Corporation, Point Hope
Fish and Game Advisory Board, Deering
Kikiktakruk Inupiat Corporation, Kotzebue
Kotzebue Elders Council
Alaska Area Native Health Service, Anchorage
Kotzebue Fire Department
Ninilchik Native Association
Mayor Sigfried Aukongak, Golovin
Village Council, Nuiqsut
City Council, Barrow
Point Lay Village Council, Point Lay
Kaktovik Inupiat Corporation, Kaktovik
Olgoonik Corporation, Wainwright
Village Council, Kaktovik
Village Council, Point Hope
Anaktuvuk Pass Village Council, Anaktuvuk Pass
Atkasook Village Council, Barrow
Village Council, Atkasook
Wainwright City Council, Wainwright
Kuukpik Corporation, Nuiquat
Maniilaq, Kotzebue
Mayor Joe Hill, Kotzebue
Mayor Eugene Brower, North Slope Borough, Barrow
Kotzebue Technical Center
Northwest Arctic School District, Kotzebue
Golovin Native Corporation, Golovin
Ahtna, Inc., Anchorage
Aleut Corporation, Anchorage
Arctic Slope Regional Corporation, Barrow

Bering Straits Native Corporation, Nome
Bristol Bay Native Corporation, Anchorage and Dillingham
Calista Corporation, Anchorage
Chugach Natives, Inc., Anchorage
Cook Inlet Region, Inc., Anchorage
Doyon Ltd., Fairbanks
Koniag, Inc., Kodiak
NANA Regional Corporation, Anchorage and Kotzebue
Sealaska Corporation, Juneau

MEDIA

KOTZ, Kotzebue
KUAC-FM, Fairbanks
Tundra Times, Anchorage
All-Alaska Weekly, Fairbanks
Yukon Sentinel, Fort Wainwright
Alaska Industry Magazine, Anchorage
Anchorage Daily News
Anchorage Times
Marine Digest, Seattle, WA
Cheechako News, Kenai
Nome Nugget
The Peninsula Clarion, Kenai
Alaska Construction and Oil Report, Anchorage
The Associated Press, Anchorage
Daily Journal of Commerce, Seattle, WA
Daily News Miner, Fairbanks

INTERESTED GROUPS AND BUSINESSES

National Parks and Conservation Association, Washington, D.C.
AEIDC, University of Alaska, Anchorage
Alaska Center for the Environment, Anchorage
National Audubon Society, Anchorage
Sierra Club, Anchorage
Trustees for Alaska, Anchorage
Northern Alaska Environmental Center, Fairbanks
National Wildlife Federation, Washington, D.C.
Everest Minerals Corporation, Corpus Christi, TX
Pierce-Atwood-Scribner, Portland, ME
GCO Minerals, Anchorage, Kotzebue; and Houston, TX
Cominco Engineering Services, Ltd., Northport, WA
Dames & Moore, Anchorage; Seattle, WA and Golden, CO
EVS Consultants, Sidney, British Columbia, Canada
L.A. Peterson and Associates, Fairbanks
Robertson, Monagle, Eastaugh and Bradley, Juneau
Getty Mining Company, Salt Lake City, UT
Wright-Forssen Association, Seattle, WA
U.S. Borax, San Francisco, CA
Northwest Alaska Chamber of Commerce, Nome
Kotzebue Sound Area Fisheries, Kotzebue

Yutana Barge Lines, Nenana
Alaska Legal Services, Barrow
Golovin Fisheries, Golovin
Alaska Riverways, Inc., Fairbanks
Arctic Lighterage, Kotzebue
Doyon Construction, Fairbanks
I.U.O.E. Local 302, Fairbanks and Juneau
Labor Local 942, Fairbanks
Alaska Oilfield Services, Anchorage
Shell Oil Co., Anchorage
District Council of Laborers, Anchorage
Alaska Pacific Bank, Anchorage
Alaska International Air, Anchorage
ARCO Alaska, Anchorage
Woodward-Clyde Consultants, Anchorage
Yutan Construction, Fairbanks
Fairbanks Sand and Gravel, Fairbanks
Bering Straits CRSA Board, Unalakleet
Rural CAP, Anchorage
Alaska Miners Association, Anchorage
Envirosphere Company, Bellevue, WA
Boatel Rocky Mountain, Denver, CO
Agri Environment Systems, Hudsonville, MI
Pacific Marine Center, Seattle, WA
Alaska Railroad, Anchorage
Sitka Conservation Society, Sitka
Alaska Maritime Agencies, Inc., Valdez
Foss Launch and Tug Co., Anchorage and Seattle, WA
Campbell Towing Co., Wrangell
Crowley Maritime Corp., Seattle, WA
Canonie Pacific, Portland, OR
AMMCO, Nashville, TN
Sliattery Equipment, Seattle, WA
EMRA, Gresham, OR
Foss Alaska Lines, Sitka
Alaska Freight Services, Seattle, WA
Best Pipe and Steel, Seattle, WA
Raymond International Builders, Houston, TX
Skyline Steel Corp., Larkspur, CA
Wright Construction Co., Seattle, WA
Only Way Construction, Sitka
Underwater Construction, Inc., Anchorage
Chevron Shipping Co., Edmonds, WA
Samson Tug and Barge Co., Sitka
Puget Sound Tug and Barge, Anchorage
Maskell-Robbins, Inc., Anchorage
Plumbers and Pipefitters Local 262, Juneau
Blue Water Marine Supply, Houston, TX
Swalling Construction Co., Anchorage
Sandstrom Sons, Inc., Anchorage
Leigh Flexible Structures Ltd., Buffalo, NY
United McGill Corp., Columbus, OH
HWW Consultants, Anchorage

Moolin and Associates, Anchorage
Alaska Explosives Ltd., Anchorage
Great Lakes Dredge and Dock Co., Oak Brook, IL
Lounsbury and Associates, Anchorage
S&G Construction Co., Anchorage
Burrell Heppner Construction Co., Anchorage
Oceaneering International, Inc., Santa Barbara, CA
Marinas International Ltd., McLean, VA
Associated Sand and Gravel Co., Elma, WA
Reidel International, Portland, OR
Mississippi Valley Equipment, Ontario, CA
Nordic Marine Floats, Everett, WA
MEECO Marinas, Inc., McAlester, OK
Alaska Resource Analysts, Inc., Anchorage
ABAM Engineers, Inc., Federal Way, WA
ERTEC Northwest, Anchorage
A.C. Hoyle Co., Iron Mountain, MI
Peter Kiewit Sons, Anchorage
Petroleum Information Corp., Anchorage
NORTEC, Anchorage
J.G. Fisher and Associates, Anchorage
Thompson Flotation, Inc., Newport Beach, CA
Alaska Diving Service, Ketchikan
I.U.O.E., Anchorage
Johnson Division, UOP, St. Paul, MN
Coast Marine Construction, Portland, OR
Teledyne Pipe, Galveston, TX
Construction and Rigging, Anchorage
Pacific NW Waterways Association, Vancouver, WA
Project Proposal Northwest, Seattle, WA
Bellingham Marine Industries, Bellingham, WA
SKW Clinton, Inc., Anchorage
Dravo Corporation, Pittsburgh, PA
Green Construction Co., Anchorage
Amak Towing, Ketchikan
Willamette-Western Corp., Portland, OR
L.B. Foster Co., Anchorage and Federal Way, WA
Teamster Local 959, Anchorage
Dillingham Construction, Anchorage
Chevron USA, Anchorage
Trident Marine, South Haven, MI
Alaska Oil & Gas Commission, Anchorage
Kaiser Steel Corp., Oakland, CA
Rotocast Plastic Products, Brownwood, TX
TAMS Engineers, Anchorage
Washington Fish & Oyster Co., Seattle, WA
Pan-Alaska Fisheries, Inc., Kodiak
Mitchell Marine, Lafayette, LA
Columbia-Ward Fisheries, Seattle, WA
Topper Industries, Inc., Vancouver, WA
Kalispel Marine Structures, Cusick, WA
West Build Structures, Portland, OR
Morrison-Knudsen Co., Boise, ID

Far West Modular, Inc., Jefferson, OR
Zebron Corp., Tualatin, OR
Gulf-Navigation, Seward
Martech International, Anchorage
General Construction Co., Seattle, WA
Piledrivers Local 2520, Anchorage
Elmer Rasmussen Library, University of Alaska, Fairbanks
Earthmovers of Fairbanks, Fairbanks
DMC Properties, Inc., Redmond, WA
National Mechanical Contractors, Anchorage
BP AK Exploration, Inc., San Francisco, CA
Nicolon Corp., Atlanta, GA
ERIS, Anchorage
Reading & Bates Construction, Houston, TX
Marathon Oil Co., Anchorage
McDonald Industries, Anchorage
Morris Marine Consultants, Anchorage
Harding Lawson Associates, Anchorage and Novato, CA
Texota, Inc., Rochester, MN
Pacific Management and Engineering, Anchorage
Construction Resources, Anchorage
Roger and Babler, Anchorage
Armortec, Norcross, GA
Gulf Oil, Anchorage
Emerald International Sales, Houston, TX
Yutana Barge Lines, Inc., Nenana
Alaska Legal Services Corp., Barrow
Alaska Riverways, Fairbanks
Arktos Associates, Anchorage
Steffen Robertson and Kirsten, Lakewood, CO
Union Oil Co., Anchorage
Sohio Alaska Petroleum Co., Anchorage

INTERESTED CITIZENS

Mike Nies, Boulder, CO
Robert Weeden, Fairbanks
Robert W. Sprague, Placentia, CA
Judy Larquiere, Fairbanks
Louie Larquiere, Fairbanks
Kate Wedemeyer, Fairbanks
Mark Standley, Fairbanks
Bob Ritchie, Fairbanks
Paul R. Huff, Fairbanks
Jacquelline La Perriere, College
James W. Alderich, Fairbanks
Nina Mollett, Fairbanks
Bob Dittrick, Anchorage
Mike Holloway, Indian
H. Paul Friesema, Evanston, IL
Pat Metz, Anchorage
Rachel Craig, Kotzebue

Rita E. Ryder, Kotzebue
Clara Taylor, Kotzebue
Paula Anderson, Kotzebue
Henry McLuke, Kotzebue
Joe Hill, Kotzebue
Lou Jones, Kotzebue
Reggie Joule, Kotzebue
Kent Hall, Kotzebue
Bev Minn, Kotzebue
Reed Henry, Kotzebue
Boris McLuke, Kotzebue
Marie A. Jones, Deering
Robin Pritkin, Seattle, WA
Roger Burggriff, Fairbanks
Ed Bur, College
Burt Adams, Kivalina
Jack Morrow, Valdez
Herbert Zieske, Pt. Baker
George Atkinson, Jr., Anchorage
Bruce Barrett, Craig
Andrew Hughes, Juneau
J. Phillip Henry, Anchorage
John Osias, Seattle, WA
Tim Sutherland, Vancouver, WA
Bill Miller, Olympia, WA
Jim Glaspell, Eagle River
Nancy Hemming, Anchorage
Leo Roberts, Kenai
Chuck Muscio, Anchorage
P. Massey, Juneau
James McElroy, Anchorage
Felix Toner, Juneau
Betzi Woodman, Anchorage
Phillip Mathew, Sherman Oaks, CA
P. Robinson, San Francisco, CA
Robert Arvidson, Cordova
John Spencer, Portland, OR
David Vick, Houston, TX
Frederick Goettel, Leonard, MD
Marie Adams, Anchorage
Scott Edson, Palmer
Bob Kent, Washington, D.C.
Richard Ehrlich, Kotzebue

X. PUBLIC RESPONSE TO DEIS

To be completed after formal DEIS comment period.

XI. REFERENCES CITED

REFERENCES

Alaska Department of Fish & Game. 1981. Management units pamphlet. Valid as of July 1, 1981.

Alaska Department of Labor. 1970. Statistical quarterly.

________. 1980. Statistical quarterly.

________. 1983. Alaska population overview, 1982.

Alt, K. T. 1978. Inventory of cataloging of sport fish and sport fish waters of western Alaska. Wulik-Kivalina Rivers study. In: Alaska Department of Fish & Game, Sport Fish Investigations, Vol. 19, Study G-I-P.

________. 1983a. Alaska Department of Fish & Game internal memo to Scott Grundy, Habitat Division, January 6, 1983.

________. 1983b. Alaska Department of Fish & Game internal memo to Al Townsend, Habitat Division, November 1, 1983.

________. 1983c. Pers. Comm. Fisheries Biologist, Alaska Department of Fish & Game, Fairbanks, AK.

Balding, G. O. 1976. Water availability, quality, and use in Alaska. U.S. Geological Survey Open-File Report 76-513. 236 pp.

Barnes, C. A. and T. G. Thompson. 1938. Physical and chemical investigation in the Bering Sea and portions of the north Pacific Ocean. Univ. of Washington Publications in Oceanography, Vol. 3, No. 2, pp. 35-79. Seattle, WA.

Bear Creek Mining Company. 1983. Testimony of Bear Creek Mining Company concerning proposed rule: Transportation and utility systems in and across, and access into, conservation system units in Alaska, September 16, 1983, Anchorage, AK.

Bendock, T. N. and K. T. Alt. 1981. Sport fish investigations of Alaska inventory and cataloging: annual performance report. Alaska Department of Fish & Game, Sport Fish Division, Juneau, AK, Vol. 22.

Benoit, D. A., E. N., Leonard, G. M., Christensen, and J. T. Fiandt. 1976. Toxic effects of cadmium on three generations of brook trout (Salvelinus fontinalis). Trans. Amer. Fish. Soc. 105(4): 550-560.

Braham, H. W. and B. D. Krogman. 1977. Population biology of the bowhead (Balaena mysticetus) and beluga (Delphinapterus leucas) whale in the Bering, Chukchi, and Beaufort Seas. Northwest and Alaska Fisheries Center Processed Report, Seattle, WA. 29 pp.

________, M. A. Fraker, and B. D. Krogman. 1980. Spring migration of the western Arctic population of bowhead whales. Marine Fishery Review 42(9-10):36-46.

Braund & Associates. 1983. Kivalina and Noatak subsistence use patterns. Ch. 7. Environmental baseline studies, Red Dog Project. Prepared for Cominco Alaska, Inc.

Brower, W. A. et al. 1977. Climatic atlas of the outer continental shelf waters and coastal regions of Alaska. Vol. III. Chukchi-Beaufort Sea. National Climatic Center and Arctic Environmental Information and Data Center.

Brown, J. and R. Berg (eds.). 1980. Environmental engineering and ecological baseline investigations along the Yukon River-Prudhoe Bay haul road. CRREL Report No. 80-19. 187 pp.

________, P. C. Miller, L. L. Tieszen, and F. Bunnell. 1980. An Arctic ecosystem. Stroudsburg, PA: Dowden, Hutchingon & Ross. 571 pp.

Burns, J. J. 1983. Pers. Comm. Marine Mammal Research Supervisor, Alaska Department of Fish & Game, Fairbanks, AK.

Burns, J. J. and T. J. Eley. 1978. The natural history and ecology of bearded seal (Erignathus barbatus) and ringed seal (Phasa hispids). In: Environmental Assessment of the Alaska Continental Shelf, Vol. 1. OCSEAP, NOAA/BLM, Boulder, CO.

________, and S. J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4).

________, L. H. Shapiro, and F. H. Fay. 1981. Ice as marine mammal habitat in the Bering Sea. pp. 781-797. In: D. W. Hood and J. Calder (eds.). The eastern Bering Sea shelf. Inst. Mar. Sci., Fairbanks.

Childers, J. M. and D. R. Kernodle. 1981. Hydrologic reconnaissance of the Noatak River basin, Alaska, 1978. U.S. Geological Survey Water Resources Investigations Open-File Report 81-1005. 38 pp.

____________, and R. M. Loeffler. 1979. Hydrologic reconnaissance of western Arctic Alaska, 1976 and 1977. U.S. Geological Survey Open-File Report 79-699. 70 pp.

Clarke, R. McV. 1974. The effects of effluents from metal mines on aquatic ecosystems in Canada. A literature review. Environment Canada, Fisheries and Marine Service, Technical Report No. 488.

Cominco Alaska, Inc. 1983a. Red Dog Mine, Project Overview. January 1983.

________. 1983b. Draft recreation report, Red Dog Project. July 1983.

________. 1983c. Draft, Analysis of options, Red Dog Project. July 1983.

Cominco Engineering Services, Ltd. 1983a. Application of the HDS process in the treatment of Red Dog tailings pond water. January 1983.

________. 1983b. Wastewater collection and management, Red Dog Project. May 1983.

Cowles, C. J. 1981. Biological assessment for endangered whales of the Arctic Region with respect to proposed offshore oil and gas exploration. Bureau of Land Management, Alaska OCS office. 42 pp.

Dames & Moore. 1982a. Vegetation - wetland communities, Red Dog Project. Prepared for Cominco Alaska, Inc. 31 pp.

________. 1982b. Final report. Port site preliminary studies for Cominco Alaska, Inc. 5438-055-20, October 8, 1982.

________. 1983a. Environmental baseline studies, Red Dog Project. Prepared for Cominco Alaska, Inc., Anchorage, AK.

________. 1983b. Supplement to environmental baseline studies, Red Dog Project. Prepared for Cominco Alaska, Inc., Anchorage, AK.

________. 1983c. Air quality impact analysis, Red Dog Project. Prepared for Cominco Alaska, Inc., Anchorage, AK.

De Cicco, A. 1982. Inventory and cataloging of sport fish and sport fish waters of western Alaska. Part A: Arctic char life history study. In: Alaska Department of Fish & Game, Sport Fish Investigations, Vol. 23, Study G-I-P-A.

________. 1983. Pers. Comm. Fisheries Biologist, Alaska Department of Fish & Game, Fairbanks, AK.

________. (In press). Inventory and cataloging of sport fish and sport fish waters of western Alaska. In: Alaska Department of Fish & Game, Sport Fish Investigations, Vol. 24, Study G-I-P.

E.V.S. Consultants Ltd. 1983. Toxicological, biophysical and chemical assessment of Red Dog Creek, De Long Mountains, Alaska, 1982. Prepared for Alaska Department of Environmental Conservation, Juneau, AK. 245 pp.

Feulner, A. J., J. M. Childers, and V. W. Norman. 1971. Water resources of Alaska. U.S. Geological Survey Open-File Report. 60 pp.

Fleming, R. H. and D. Heggarty. 1966. Oceanography of the southeastern Chukchi Sea. pp. 697-754. In: N. J. Wilimovsky and J. N. Wolfe (eds.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN, Pub. PNE-481.

Frost, C. 1983. Pers. Comm. Marine Mammal Research Biologist, Alaska Department of Fish & Game, Fairbanks, AK.

Giddings, J. L. 1967. Ancient men of the Arctic. New York: Alfred A. Knopf.

_________ and D. D. Anderson. In press. Prehistory of northwest Alaskan Eskimo settlements and culture: Beach ridge archaeology of Cape Krusenstern and other sites around Kotzebue Sound.

Gregory, L. 1974. The effect of effluent components from chlor-alkali plants on aquatic organisms. A literature review. Fisheries Research Board of Canada. Technical Report No. 228.

Hall, E. S., Jr. 1982a. A cultural resource site reconnaissance performed in conjunction with development of the Red Dog mine, northwestern Alaska. Report to Cominco Alaska, Inc. Edwin S. Hall and Associates, Technical Memorandum #1.

_________. 1982b. Project specific cultural resource site inventory: The Red Dog project. Report to the Bureau of Land Management. Edwin Hall and Associates, Technical Memorandum #3.

_________. 1983a. Preliminary supplement: A cultural resource site reconnaissance performance in conjunction with development of Red Dog mine, northwestern Alaska. Report to Cominco Alaska, Inc. Edwin Hall and Associates, Technical Memorandum #5.

_________. 1983b. Pers. Comm. Edwin S. Hall and Associates.

Hawley, J. R. 1972. Use, characteristics and toxicity of mine-mill reagents in Ontario. Ontario Ministry of the Environment.

Hopkins, D. M. 1977. Coastal processes and coastal erosional hazards to the Cape Krusenstern archeological site. U. S. Geological Survey Open-File Report 77-32. 17 pp.

Houghton, J. 1983. Pers. Comm. Fisheries Biologist, Dames & Moore, Seattle, WA.

Jansons, U. and R. G. Bottge. 1977. Economic mining feasibility studies of selected mineral deposit types in the western Brooks Range, Alaska. U.S. Bureau of Mines Open-File Report 128-77.

John Muir Institute, 1983. The regional socioeconomics of Norton Sound (draft), prepared for Minerals Management Service, Alaska OCS Office.

Johnson, A. W., L. A. Viereck, R. E. Johnson, and H. Melchior. 1966. Vegetation and flora. In: N. J. Wilimovsky and J. N. Wolfe (eds.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN, Pub. PNE-481.

Johnson, C. 1983. Pers. Comm. Marine Mammal Biologist, National Marine Fisheries Service, Anchorage, AK.

Kevin Waring Associates. 1983. Socioeconomic forecasts for the NANA Region. Unpub. data.

LGL Ecological Research Associates, Inc. 1980. Baseline aquatic investigations of fish and heavy metal concentrations in the Kivalina and Wulik Rivers, 1978-1979. Prepared for GCO Minerals Co.

Louis Berger & Associates. 1981. Western and Arctic Alaska transportation study. Prepared for State of Alaska, Department of Transportation and Public Facilities.

Marquette, W. M. and H. W. Braham. 1982. Grey whale distribution and catch by Alaska Eskimos: A replacement for the bowhead whale? Arctic 35(3).

Mauneluk Association. 1974. The NANA region; its resource and development potential. Prepared for U.S. Economic Development Authority and the U.S. Bureau of Indian Affairs, Juneau, AK.

_________. 1979. Subsistence. A summary of available information about the NANA Region.

McVey, R. W. 1983. Pers. Comm. Director, Alaska Region, National Marine Fisheries Service, Juneau, AK.

Moore, G. W. 1966. Arctic beach sedimentation. pp. 587-608. In: N. J. Wilimovsky and J. N. Wolfe (eds.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN, Pub. PNE-481.

Muller, S. W. 1947. Permafrost or permanently frozen ground and related engineering problems. Military Intelligence Division, Chief Engineer, U.S. Army office, Special Report, Strategic Engineering Study 62. 231 pp.

Murray, D. F. 1980. Threatened and endangered plants of Alaska. U.S.D.A. and U.S.D.I. Coop. Forest Service and Bureau of Land Management Report, Contr. No. 53-0109-9-00014. 59 pp.

Noah, H. 1983. Pers. Comm. Environmental Coordinator, Cominco Alaska, Inc., Anchorage, AK.

Olson, J. E. 1982. The effects of air pollution and acid rain (Report 8) on fish, wildlife and their habitats - Arctic tundra and alpine meadows. FWS/OBS 80/40.8. U.S. Department of the Interior, Washington, D. C. 70 pp.

Ott, A. 1983. Pers. Comm. Regional Habitat Supervisor, Alaska Department of Fish & Game, Fairbanks, AK.

Rae, J. A. 1983. Pers. Comm. Red Dog Project Manager, Cominco, Ltd., Trail, B.C., Canada.

Reeder, S. W., A. Demayo and M. C. Taylor. 1979. Guidelines for surface water quality. Vol. 1. Inorganic Substances, Cadmium. Environment Canada, Inland Waters Directorate, Ottawa. 19 pp.

Rugh, D. J. and J. C. Cubbage. 1980. Migration of bowhead whales past Cape Lisburne, Alaska. Mar. Fish. Rev. 42:46-51.

Saario, D. J. and B. Kessel. 1966. Human ecological investigations at Kivalina. In: N. J. Wilimovsky and J. N. Wolfe (eds.). Environment of the Cape Thompson region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN, Pub. PNE-481.

Selkregg, L. L. 1974. Alaska regional profiles. Northwest region. University of Alaska, Arctic Environmental Information and Data Center. 265 pp.

Sellmann, P.V., J. Brown, R. I. Lewellen, H. McKin, and C. Merry. 1975. The classification and geomorphic implications of thaw lakes on the Arctic coastal plain, Alaska. Research Report 344, Cold Regions Research and Engineering Laboratory, Hanover, NH. 21 pp.

Shaver, M. 1983. Pers. Comm. Superintendent, Cape Krusenstern National Monument, National Park Service, Kotzebue, AK.

Smith, H. L. 1982. Archaeological investigations in the DeLong Mountains, northwest Alaska, 1979-1980. Bureau of Land Management, Fairbanks, AK.

Social Research Institute. 1982. NANA coastal resource service area coastal management plan: The people.

Specht, W. L. 1973. The effect of heavy metals upon the diversity and abundance of benthic macroinvertebrates. M.S. Thesis, Penn. St. Univ. 58 pp.

Sprague, J. B., P. F. Elson, and R. L. Saunders. 1965. Sublethal copper-zinc pollution in a salmon river -- a field and laboratory study. Int. J. Air, Water Pollut. 9:531-543.

Springer, A. M. and D. G. Roseneau. 1977. A comparative sea-cliff bird inventory of the Cape Thompson vicinity, Alaska. pp. 206-262. In: Environmental assessment of the Alaska Continental Shelf. Annual reports of principal investigators for the year ending March 1977. Vol. 5. Receptors-birds. Nat. Oceanic and Atmos. Admin., U.S. Dept. of Commerce.

______________. 1982. Population and trophics studies of seabirds in the northern Bering and Chukchi Seas, 1981. In: Environmental assessment of the Alaskan continental shelf. Annual reports of principal investigators for the year ending March 1982. Nat. Oceanic and Atmos. Admin., U.S. Dept. of Commerce.

Tailleur, D. L. 1970. Lead-, zinc-, and barite-bearing samples from the western Brooks Range, Alaska. U.S. Geological Survey Open-File Report 70-319.

Tsytovich, N. A. 1975. The mechanics of frozen ground. New York: McGraw Hill Book Co.

U. S. Department of Commerce, Bureau of Economic Analysis. 1982. Personal income and employment by major source, 1967 to 1981.

U. S. Environmental Protection Agency. 1983. Responsiveness summary for scoping meetings, February 14 through April 1, 1983 on Red Dog Mining Project EIS.

Viereck, L. A., C. T. Dyrness, and A. R. Batten. 1981. Revision of preliminary classification system for vegetation of Alaska. U.S.D.A., Forest Service General Technical Report PNW-106. 64 pp.

WGM, Inc. 1978. Mineral studies of the western Brooks Range. Vol. I & II. U.S. Bureau of Mines, Contract No. J0155089.

Winslow, P. C. 1968. Notes on biology of Wulik River char (unpublished). Alaska Department of Fish & Game, Division of Sport Fish, Juneau, AK.

Woodward-Clyde Consultants. 1983. Coastal sedimentations: Cape Thompson to Cape Krusenstern.

Wunnicke, E. C. 1983. Department of Natural Resources, Office of the Commissioner letter to W. H. Tonking, GCO Minerals and H. M. Giegerich, Cominco Alaska, March 9, 1983.

XII. GLOSSARY OF TECHNICAL TERMS, ACRONYMS AND ABBREVIATIONS AND MEASUREMENT EQUIVALENTS

DEFINITION OF TERMS

Technical Term	Definition
alluvium	Material deposited by moving water.
anadromous	Fish which go up rivers from the sea to spawn.
aufeis	Icings formed from pressurized flows of streams or groundwater.
borrow site	Site from which road construction materials (gravel) would be extracted.
chelation	Reaction which causes central atom (usually a metal ion) to attach to neighboring atoms to form a ring structure.
diachronic	Through time.
epibenthic	Existing on the surface of bottom material.
epifauna	Community of organisms which live on or just beneath the surface of bottom material.
euryhaline	Capable of withstanding wide variations in salinity.
halophytic	Adapted to grow in salty or alkaline soil.
hydric	Characterized by an abundance of moisture.
hydrophyte	Plant growing only in water or very wet earth.
igneous	Formed by volcanic action or intense heat.
infauna	Community of organisms which live within bottom material.
lighter	Open barge used for transporting goods between ships and shore in shallow water.

Technical Term (Continued)	Definition
lightering	Using open barges in loading and unloading of larger ships where shallow waters prevent normal docking.
mafic	Pertaining to igneous rocks rich in magnesium and iron, and relatively low in silica.
mesic	Moist, or requiring moderate amounts of moisture.
moraine	Mass of rocks, gravel, sand, clay, etc., carried and then deposited by a glacier along its sides, at its terminus, or underneath the ice.
natal stream	Stream in which a fish is born.
oligochaeta	Class of segmented worms; found chiefly in moist soils and fresh water.
orographic	Pertaining to mountains.
polynya	Semi-permanent open lead in sea ice.
project area	Refers to the entire area encompassed by proposed project components. Generally bounded by the Singoalik Lagoon port site, the GCO transportation corridor, Red Dog Valley, the Mulgrave Hills, VABM 28 and an undetermined distance out to sea.
rolligon	Cushion-wheeled vehicle used for crossing tundra with minimal damage.
scree	A heap of rock waste at the base of a cliff or a sheet of coarse, loose debris lying on a mountain slope.
sealift	Large seasonal movement of cargo by ships from distant points to the project area.
seismic	Related to, or caused by, earthquakes or man-made earth tremors.
solifluction	The process of slow downslope movement of water-saturated earth.
tailings	The waste products of the milling process that are disposed of in the tailings pond.
tailings pond	The area created by a dam to hold the mill tailings.
thaw bulb	Unfrozen zone in permafrost area, usually around lake, stream, or man-made structure.

Technical Term (Continued)	Definition
thermocline	Layer of water between warmer surface zone and colder, deeper waters in which temperature decreases rapidly with depth.
Title XI	The part of the Alaska National Interest Lands Conservation Act (ANILCA) that provides a mechanism for the Secretary of the Interior to grant access through certain reserved lands in Alaska (e.g., Cape Krusenstern National Monument).
trophic	Related to nutrition.
ungulate	A hoofed mammal.
xeric	Related to, or having dry or desert-like conditions.
xerophytic	Adapted to growing under very dry or desert-like (xeric) conditions.

AGENCY ACRONYMS AND ABBREVIATIONS

Federal Agencies

ACHP	Advisory Council on Historic Preservation
BLM	Bureau of Land Management
Corps	Army Corps of Engineers
DA	Department of the Army
DOI	Department of Interior
EPA	Environmental Protection Agency
FWS	Fish and Wildlife Service
MSHA	Mining Safety and Health Administration
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
USGS	United States Geological Survey

State of Alaska Agencies

ADF&G	Alaska Department of Fish and Game
AEIDC	University of Alaska, Arctic Environmental Information & Data Center
DEC	Department of Environmental Conservation
DGGS	Division of Geological and Geophysical Survey
DNR	Department of Natural Resources
SHPO	State Historic Preservation Office

Other

ANCSA	Alaska Native Claims Settlement Act of 1971
ANILCA	Alaska National Interest Lands Conservation Act of 1980
BACT	Best Available Control Technology
HDS	High Density Sludge
IRA	Indian Reorganization Act
NAAQS	National Ambient Air Quality Standards
NANA	NANA Regional Corporation (originally: Northwest Alaska Native Association)
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NSB	North Slope Borough
NSPS	New Source Performance Standards
ORV	Off-road Vehicles
PSD	Prevention of Significant Deterioration
SPCC	Spill Prevention, Control and Countermeasure Plan
VLCC	Very Large Crude Carrier
VQO	Visual Quality Objective

METRIC/ENGLISH MEASUREMENT, ABBREVIATIONS AND EQUIVALENTS

Metric Unit (Abbrev.)	Equivalent	English Unit (Abbrev.)
centimeter (cm)	2.54 cm = 1 in	inch (in)
meter (m)	0.3048 m = 1 ft	foot (ft)
kilometer (km)	1.6093 km = 1 mi	mile (mi)
hectare (ha)	0.4047 ha = 1 ac	acre (ac)
square kilometer (km^2)	2.590 km^2 = 1 mi^2	square mile (mi^2)
liter (ℓ)	3.7854 ℓ = 1 gal	gallon (gal)
cubic meter (m^3)	0.0283 m^3 = 1 ft^3	cubic feet (ft^3)
cubic meter (m^3)	0.7646 m^3 = 1 yd^3	cubic yard (yd^3)
cubic dekameter (dam^3)	1.2335 dam^3 = 1 ac-ft	acre-foot (ac-ft)
cubic meter per second (m^3/s)	0.0283 m^3/s = 1 ft^3/s	cubic feet per second (ft^3/s)
kilogram (kg)	0.4536 kg = 1 lb	pound (lb)
megagram (Mg)	0.9072 Mg = 1 ton	short ton (2,000 lb)
meter per second (m/s)	0.5144 m/s = 1 knots	knot (knot)
meter per second (m/s)	0.3048 m/s = 1 ft/s	feet per second (ft/s)
miligram per liter (mg/ℓ)	1.0 mg/ℓ = 1 ppm	part per million (ppm)
degrees Celsius (°C)	(1.8x°C)+ 32 = °F	degrees Fahrenheit (°F)
barrels (bbls)		barrels (bbls)

XIII. INDEX

Active layer: IV-8
ADF&G: (see Alaska Department of Fish & Game)
Advisory Council on Historic Preservation (ACHP): I-9, V-25, V-71, V-81, V-93, VI-8
Air quality: IV-49, V-17, V-66, V-81, V-83, V-92, VI-8
Aircraft flights: V-69
Airstrip: II-13, V-85
Alaska Department of Environmental Conservation (DEC): I-9, V-82, VI-9
Alaska Department of Fish & Game (ADF&G): I-9, V-42, V-46, V-80, V-90, VI-9
Alaska Department of Natural Resources (DNR): I-4, I-9, V-75, VI-9
Alaska National Interest Lands Conservation Act (ANILCA): I-1, III-36, III-41, IV-1, V-93, V-97
Alaska Native Claims Settlement Act (ANCSA): I-2, IV-1
Alluvial deposits: IV-5, IV-7
Alternatives 1, 2 and 3: III-39, III-44, V-36
Ambler District: V-88
Anadromous fish: (see Fish)
Appendix 1, Reclamation Plan: V-83
Appendix 2, Spill Prevention, Control and Countermeasure (SPCC) Plan: V-5, V-13, V-46, V-47, V-51, V-54, V-64, V-80, V-92
Appendix 3, Endangered Species Biological Assessment: IV-12, IV-17, IV-43, VI-8
Appendix 4, NPDES Draft Permit: VI-1
Appendix 5, Department of Army Public Notice and Section 404(b)(1) Evaluation: VI-7
Appendix 6, ANILCA Title XI Right-of-Way Application: VI-7
Appendix 7, Protection of Cultural Resources: VI-8, VI-10
Archeological resources: VI-8, VI-10
Archeological sites: IV-53, V-25, V-90
Arctic char: (see Fish)
Arctic Circle: I-2
Asikpak Lagoon: IV-12, V-51
Asikpak River: II-13, III-6, IV-12, IV-19, V-39, V-45, V-48, V-51
Asikpak route: III-6, III-16, III-35, III-37
Atigun Pass: V-38, V-66
Ballasted tanker: (see Transfer facility)
Baqhalik Creek: IV-33
Barite: II-1, II-8, IV-8
Barium sulfate: II-8, V-63
Bear Creek Mining Company: V-88
Beaufort Sea: IV-42, V-60

Belukha whale: (see Marine mammals)
Benthic invertebrates: IV-30, V-13, V-49
Bering Sea: IV-42
Bering Strait: IV-43
Best Available Control Technology (BACT): V-17, V-19
Big Diomede Island: IV-43
Bioaccumulation: IV-37, V-2, V-14
BLM: (see U.S. Bureau of Land Management)
Boating: IV-71, V-74
Bons Creek: II-6, III-3, III-16, IV-25, V-16
Bons Creek water supply reservoir: II-13, V-13, V-17, V-85
Borrow sites: II-16, II-33, V-37, V-39, V-46, V-50, V-67, V-68, V-86
Bowhead whale: (see Marine mammals; c.f. Appendix 3)
Bridge: (see Road transportation system)
Brooks Range: I-2, IV-8, IV-15, V-88
Brown bear: (see Terrestrial wildlife)
Buddy Creek: III-3, IV-25
Cadmium: IV-23, IV-25, IV-29, IV-36, V-5
Campsite: III-3, V-27
Cape Krusenstern: IV-46, IV-53, V-53, V-57, V-61, V-64, V-94
Cape Krusenstern Archeological District: III-47, IV-53
Cape Krusenstern National Monument: I-1, I-4, I-8, II-19, III-7, III-47, III-48, IV-2, IV-50, IV-53, IV-72, V-23, V-71, V-74, V-88, V-90, V-97, VI-7
Cape Lisburne: I-2
Cape Seppings: V-74
Cape Thompson: IV-15, IV-42, IV-48
Caribou: (see Terrestrial wildlife)
Char overwintering habitat: (see Fish)
Chemical spills: V-2, V-5, V-38, V-45, V-47, V-54, V-61 (c.f. Appendix 2)
Chromium: IV-25, IV-29
Chukchi Sea: I-2, II-13, IV-42, IV-46
Coal: III-3, V-89
Coastal geologic processes: I-7, III-45, IV-46, V-57, V-94
Coastal Zone Management: VI-10
Cominco Alaska, Inc.: I-2, I-6
Community facilities: IV-69, V-34
Component: II-1, III-16, III-39, V-1
Concentrate spills: V-2, V-38, V-54, V-61 (c.f. Appendix 2)
Concentrate storage building: II-19, II-35, V-39, V-68
Concentrates (lead, zinc, barite): II-1, II-8, V-63
Copper: IV-29, IV-37
Copper sulfate: II-10, V-62
Corps: (see U. S. Department of Army Corps of Engineers)
Council on Environmental Quality (CEQ): I-1
Cultural resources: I-7, III-47, IV-51, V-25, V-71, V-81, V-83, V-93, VI-8, VI-10
De Long Mountains: I-2, IV-4, IV-15, V-75
Deadlock Mountain: I-2, IV-4
DEC: (see Alaska Department of Environmental Conservation)
Department of the Army (DA): IV-10, VI-1, VI-7
Development schedule: II-33
Diachronic model: IV-53

Diesel fuel: II-13, III-3
Discharge standards: II-12, V-7, V-9
Diversion ditch: II-4, V-4, V-5, V-80, V-82
Division of Geological and Geophysical Survey (DGGS): V-89
DNR: (see Alaska Department of Natural Resources)
DOI: (see U.S. Department of the Interior)
Domestic wastewater: II-19, V-8, V-80
Dredging: II-30, V-52, V-53, V-59
Dudd Creek: II-13, III-3, IV-25, IV-37
Dust: V-2, V-17, V-19, V-38, V-66, V-81, V-91
Economy: I-7, III-48, IV-65
Emissions: V-17, V-21, V-66
Employment: IV-66, V-26
Endangered species: IV-11, IV-17, IV-43, VI-8 (c.f. Appendix 3)
EPA: (see U.S. Environmental Protection Agency)
EPA Significant Emission Rates: V-17, V-21
Erosion: V-14, V-38, V-46, V-59
Eschscholtz Bay: IV-42
Evaingiknuk Creek: III-7
Evaporation: IV-48, V-7
Fish: I-7, II-13, II-16, III-44, V-14, V-50, V-72, V-82, V-100
    Anadromous fish: IV-32, IV-40, V-46, V-52, V-55, V-101
    Arctic char: IV-36, IV-40, IV-54, IV-59, IV-72, V-14, V-25, V-73, V-101
    Arctic grayling: IV-32, IV-36, IV-40, IV-72, V-14, V-50
    Char overwintering habitat: II-13, IV-32, V-51
    Char rearing habitat: V-50, V-51
    Char spawning habitat: II-32, IV-32, V-50, V-51
    Chum salmon: IV-33, IV-40, IV-54, IV-59, IV-72
    Coho salmon: IV-33
    King salmon: IV-33
    Migration: IV-37, V-50, V-51, V-54
    Pink salmon: IV-33, IV-40
    Salmon: IV-36, V-14, V-51
    Sockeye salmon: IV-33
    Tissue: IV-37, V-15
Fishing: IV-71, V-16, V-26, V-36, V-52, V-74, V-81, V-90, V-100
Fivefingered Creek: IV-33
Floodplains: IV-7
Fuel: II-19, II-32, V-61
Fuel spills: V-2, V-5, V-38, V-45, V-47, V-54, V-61 (c.f. Appendix 2)
FWS: (see U.S. Fish and Wildlife Service)
Garbage collection: V-4, V-80
GCO Minerals Company: I-2, III-3, V-88
GCO route: III-3, III-16, III-35, III-37
Glacial moraine: IV-4
Golden eagle: (see Terrestrial wildlife)
Gray whale: (see Marine Mammals; c.f. Appendix 3)
Grayling Creek: II-16, IV-33, V-47
Groundwater: IV-17, IV-29, V-4, V-45, V-80, V-82
High Density Sludge (HDS) process: II-12, V-9
Hotham Inlet: III-8, III-37
Hovercraft: III-7
Hunting: IV-71, V-26, V-36, V-74, V-81, V-90, V-100

Hydrology: IV-19, V-5, V-46, V-80, V-82, VI-9
Hydropower: III-3
Ice: IV-47, V-60
Ice-wedge polygons: IV-5
Icings: IV-7, IV-19, V-47, V-48, V-82
Ikalukrok Creek: II-13, IV-19, IV-25, IV-29, V-47, V-82
Imikruk Creek: IV-12
Imikruk Lagoon: IV-12
Income: IV-66, V-27, V-30
Inupiat Eskimos: IV-55, IV-62
Ipiavik Lagoon: IV-12, IV-20, IV-42, V-50, V-59
Iron: IV-23, IV-29
Kavrorak Lagoon: IV-42, V-51
Kivalina: I-2, II-13, III-6, IV-2, IV-19, IV-54, V-25, V-98
Kivalina Lagoon: IV-12
Kivalina River: II-13, III-6, IV-7, IV-12, IV-19, IV-23, IV-32, V-39, V-48, V-73, V-101
Kobuk National Monument: V-88
Kotlik Lagoon: IV-37
Kotzebue: I-2, II-1, IV-2, IV-54, IV-62, IV-70, V-33, V-81, V-99
Kotzebue Sound: III-8, III-37, IV-42
Kruz route: III-7, III-16, III-35, III-38, V-99
Lagoon breaching: II-30, II-32, II-33, V-39, V-43, V-52, V-59
Land exchange: I-4
Land status: IV-2
Lead: II-1, II-8, IV-8, IV-23, IV-25, IV-29, V-5
Lead sulfide: II-13
Lighter barges: II-30, II-32
Lik prospect: I-4, III-3, III-48, V-76
Lime: II-11
Manganese: IV-29
Mapsorak Lagoon: IV-37
Marine biology: I-7, III-46, IV-37, V-52
Marine birds: IV-42, V-55, V-57
Marine fish: IV-40, V-53, V-55
Marine invertebrates: IV-38, V-52
Marine mammals: IV-42, V-25, V-55, V-57, V-70, V-72, V-100, V-103
    Bearded seal: IV-42, IV-54, V-73
    Belukha whale: IV-42, IV-54, V-70, V-73
    Bowhead whale: IV-42, V-56, V-70, V-73, VI-8 (c.f. Appendix 3)
    Gray whale: IV-43, V-56, V-70, VI-8 (c.f. Appendix 3)
    Harbor porpoise: IV-42
    Polar bear: IV-43
    Ringed seal: IV-42, IV-54, V-55
    Spotted seal: IV-42, IV-54
    Walrus: IV-43, V-73
    Whale migration: IV-43, V-56, V-81
Marine water quality: IV-46, V-59, V-65, V-82
Mauneluk (Maniilaq) Association: V-72
Mercury: IV-25, IV-29
Meteorology: IV-47
Methylisobutyl carbinol: II-11
Mill: II-1, II-4, II-6, III-1, V-85

Mine: II-1, II-2, III-1, V-22, V-25, V-83
Mining Safety and Health Administration (MSHA): II-12
Mitigation: V-78
Monitoring: V-81, VI-1
Moose: (see Terrestrial wildlife)
Morgan Coal Company: V-89
Mulgrave Hills: II-13, IV-59, V-72, V-102
Muskoxen: (see Terrestrial wildlife)
NANA region: IV-62, IV-65, IV-70, V-99, VI-10
NANA Regional Corporation: I-2, II-1, III-41, IV-2, V-26, V-75, V-78, V-83
NANA/Cominco agreement: I-6, V-27, V-31, V-35, V-41, V-72, V-102
Natal streams: IV-32
National Ambient Air Quality Standards (NAAQS): V-17, V-21, V-66
National Climatic Center: IV-48
National Environmental Policy Act of 1969 (NEPA): I-1
National Marine Fisheries Service (NMFS): I-9, IV-43, VI-8
National Petroleum Reserve: III-36
National Pollutant Discharge Elimination System (NPDES) Permit: I-1, I-8, II-19, V-8, V-82
National Register of Historic Places: III-47, IV-53, V-25, V-71
Natural gas: III-3, V-87
New Heart Creek: V-50, V-72
Nickel: IV-29
NMFS: (see National Marine Fisheries Service)
No Action Alternative: III-41, V-1, V-77
Noatak: I-2, III-7, III-37, IV-2, IV-54, IV-62, V-25, V-98
Noatak corridor: III-7, III-37
Noatak National Preserve: III-36, IV-71, V-88
Noatak River: II-16, III-7, III-37, IV-7, IV-19, IV-32, IV-71, V-37
North Fork Red Dog Creek: III-3, IV-22, IV-25, V-14
North Slope Haul Road: V-38, V-66
North Slope Borough: I-10, IV-2, IV-70, V-35, V-86
Northern corridor: II-13, III-3, III-37, IV-53, V-85
NPS: (see U.S. National Park Service)
Ocean currents: IV-44
Off-road vehicles (ORVs): V-90
Ogotoruk Beach: IV-46
Ogotoruk Creek: IV-20
Ogotoruk Valley: IV-48
Oil: V-87
Omikviorok River: II-16, III-7, IV-12, IV-20, V-37, V-49, V-50, V-101
Omikviorok route: III-7, III-16, III-38
Option: II-1, III-1
Options screening criteria: III-9
Options screening process: III-8, III-16, III-39
Ore: I-2, II-1
Ore body: II-4, IV-29, IV-36, V-5
Orographic shading: IV-48
Ott Water Engineers, Inc.: I-4
Overburden: II-4, V-84
Peregrine falcon: (see Terrestrial wildlife; c.f. Appendix 3)
Permafrost: II-16, IV-5, IV-8, IV-17, V-46

pH: IV-23, IV-25, IV-29, IV-36, V-10
Physical and chemical oceanography: IV-44, V-57
Physiography: IV-5
Pingos: IV-7
Point Hope: IV-43, IV-46, IV-47, IV-62, V-53, V-61
Point Lay: V-89
Polyacrylamide flocculant: II-11
Polynya: IV-42, V-55, V-56
Population (human): IV-62, V-32
Port site: II-1, II-19, II-33, III-8, III-16, III-35, VI-1
Power generation: II-6, II-13, III-3
Power plant: II-1
Precipitation: IV-20, IV-48, V-7
Preferred alternative: III-50, V-95
Prevention of Significant Deterioration (PSD): V-17, V-21, VI-9
Project components: III-1
Prudhoe Bay: V-38, V-66
Public access: V-75, V-89
Rabbit Creek: IV-15, IV-33, V-42, V-45, V-73
Railroad: II-13, III-7, III-35
Raptors: IV-12, V-42
Reagents: II-8, V-9, V-63
Reclamation: V-15, V-83, V-86, VI-1 (c.f. Appendix 1)
Recreation: IV-70, V-36, V-74, V-83, V-93
Red Dog Creek: I2, II-2, IV-19, IV-22, IV-29, V-11, V-14, V-82
Red Dog Valley: I-2, II-33, III-3
Regional use: I-8, III-48, V-75
Revegetation: V-13, V-19, V-47, V-66, V-86 (c.f. Appendix 1)
Right-of-way: II-19, VI-7, VI-9
Road transportation system: II-16, II-33, III-7, III-35
    Bridge: II-13, II-16, V-38, V-46, V-76, V-85
    Construction: V-41, V-43, V-46, V-50, V-67, V-80
    Culvert: II-13, II-16, V-38, V-46, V-49, V-82, V-85
    Drainage: V-38, V-47
    Stream crossing: III-43, V-46, V-49, V-51, V-82, V-85
Rolligons: V-47
Runoff: IV-20, V-7
Salinity: IV-46
Salmon: (see Fish)
Scoping issues: I-6
Scoping process: I-4, III-1, III-8, III-41
Scour: V-60
Sealift: I-4, II-19, II-33
Section 10 (River and Harbors Act of 1899): I-1, VI-7
Section 404 (Clean Water Act of 1972): I-2, VI-1, VI-7
Section 7 (Endangered Species Act of 1973): VI-8
Section 810 (ANILCA): V-97, VI-7
Sediment loading: V-15, V-50
Sediment transport: IV-46, V-57, V-82
Sedimentation ponds: V-13, V-46, V-59, V-62, V-80, V-82
Seepage containment: II-6, V-5, V-13
Seismology: IV-5
Selective flotation milling process: II-8

Siaktak Hills: IV-17, V-44
Silicate: II-8
Silver: II-1, II-8, IV-8, IV-25, IV-29
Singoalik Lagoon: III-6, III-8, III-35, III-37, IV-12
Singoalik River: III-6, IV-12, V-45
Slurry pipeline: III-7
Snowfall: IV-48
Social impacts: I-7, III-48
Socioeconomics: IV-62, V-27, V-81, V-83
Sodium cetylsulfonate: II-11
Sodium cyanide: II-10, V-62
Sodium isopropyl xanthate: II-11
Soils: IV-8, IV-17
Sound: IV-51, V-23, V-68, V-70, V-81, V-93
South Fork Red Dog Creek: III-3, III-16, IV-23, IV-25, V-5, V-14
Southern corridor: II-16, III-3, III-7, III-16, III-35, III-38, IV-53, V-85, V-101
Sphagnum: IV-8
St. Lawrence Island: IV-43
State Historic Preservation Officer (SHPO): I-10, V-25, V-71, V-81, VI-10
Storm events: IV-20, V-8, V-80
Storm surges: IV-44
Subsistence: I-7, III-46, IV-54, IV-65, V-25, V-72, V-81, V-83, V-91, V-93, V-97, VI-7
Sulfides: II-1, II-8, V-63
Sulfuric acid: II-11, V-62
Tailings: II-2, V-8
Tailings pond: II-1, II-6, III-3, III-16, V-6, V-8, V-80, V-84, VI-1
Tailings pond dam: II-4, II-6
Tailings pond overflows: V-12, V-16
Tailings slurry: II-6, II-8
Tasaychek Lagoon: V-88
Terrestrial wildlife: I-7, III-45, V-3, V-40, V-79, V-82, V-92, V-100
    Brown bear: IV-17, V-3, V-42, V-44
    Caribou: IV-12, IV-54, IV-72, V-3, V-25, V-41, V-44, V-72, V-101
    Dall sheep: IV-15, V-4, V-42
    Golden eagle: IV-12, V-3
    Gyrfalcon: IV-12
    Moose: IV-15, IV-54, IV-72, V-4, V-42, V-45, V-72, V-73, V-101
    Muskoxen: IV-15, V-4, V-42, V-45
    Peregrine falcon: IV-12, IV-17, V-41, V-44, VI-8 (c.f. Appendix 3)
    Red fox: IV-17, V-3, V-44
    Rough-legged hawk: IV-12
    Shorebirds: IV-12
    Small mammals: V-3, V-40, V-42, V-44, V-101
    Song birds: V-3, V-40, V-42, V-44
    Waterfowl: IV-12, IV-54, IV-59, V-4, V-42, V-45, V-72, V-101
    Wolverine: IV-17, V-3, V-44
    Wolves: IV-17, V-3, V-44
Thaw bulb: IV-7
Thaw lake: IV-5
Thermocline: IV-47
Tides: IV-44
Title XI (ANILCA): I-1, I-4, III-16, III-37, III-41, V-75, V-91, V-97, VI-7

Title 16 (Alaska Statutes): V-46, VI-9
Total suspended solids (TSS): V-11
Townsite: III-3, V-27, V-34
Transfer facility: II-30, III-8, III-35
    Ballasted tanker: II-30, V-53, V-59, V-68, V-86
    Bulk carrier: II-30, V-65
    Buried pipeline: II-33, V-56, V-61
    Causeway/dock: II-19, III-8, III-35, V-53, V-56, V-58
    Short causeway/lightering: II-30, II-32, III-8, III-35
    Short causeway/offshore island: II-30, III-8, III-35
Transportation corridor: II-1, II-13, III-3, III-35
Transportation system: II-1, III-7, III-35
Trapping: V-26, V-36, V-74, V-90
Tugak Lagoon port site: II-1, II-13, III-6, III-8, III-35, IV-12, IV-54, V-55, V-73
Tutak Creek: IV-33, IV-37, V-41
U.S. Department of Army Corps of Engineers (Corps): I-1, I-8, VI-7
U.S. Bureau of Land Management (BLM): I-4, IV-1, V-89
U.S. Department of the Interior (DOI): I-1
U.S. Environmental Protection Agency (EPA): I-1, I-8, VI-1
U.S. Fish and Wildlife Service (FWS): I-9, VI-8
U.S. Forest Service: IV-50
U.S. National Park Service (NPS): I-1, I-4, I-9, IV-2, V-75, V-99, VI-7
VABM 17: III-7, III-38
VABM 28 port site: II-1, II-13, II-16, III-7, III-16, III-38, V-72
Vegetation: IV-8, V-2, V-36, V-39, V-79, V-82, V-91
    Herbaceous: IV-10
    Hydrophytes: IV-11
    Mat and cushion tundra: IV-9
    Shrubland: IV-9
    Tussock tundra: IV-10, V-39
Very Large Crude Carrier (VLCC): II-30 (c.f. Ballasted tanker)
Visual resources: IV-50, V-21, V-67, V-92
Volcano Creek: III-3
Volcano Mountain: V-25
Waste heat: II-6, II-8, II-13
Wastewater treatment plant: II-6, II-12
Water balance: V-5
Water quality: I-6, III-43, IV-22, IV-36, V-5, V-11, V-46, V-80, V-82, V-84, VI-9
Water recirculation: II-6, II-8
Water supply: II-12, III-3
Waves: IV-44
Western and Arctic Alaska Transportation Study (WAATS): III-6, V-88
Western route: III-7, III-16, III-38
Wetlands: IV-10, V-2, V-38, V-40, V-79, V-82, V-91, VI-7
Wind: IV-44, IV-49
Wolves: (see Terrestrial wildlife)
Worker housing: II-1, II-6, II-12, II-35, III-1, III-3, V-85
Wulik Peaks: IV-19
Wulik River: II-13, III-6, IV-7, IV-12, IV-19, IV-23, V-37, V-39, V-47, V-50, V-73, V-101
Zinc: II-1, II-8, IV-8, IV-23, IV-29, IV-36, V-5, V-11
Zinc sulfate: II-10
Zinc sulfide: II-13

XIV. LIST OF APPENDICES

---

1. Reclamation Plan
2. Spill Prevention, Control and Countermeasure (SPCC) Plan
3. Endangered Species Biological Assessment
4. NPDES Draft Permit
5. Department of Army Public Notice and Section 404(b)(1) Evaluation
6. ANILCA Title XI Right-of-Way Application
7. Protection of Cultural Resources

All appendices are bound together in a separate volume.